

The Ecological Landscapes of Wisconsin



Part 3: Supporting Materials



Appendix A. Ecosystem Management Planning Team Members

Affiliation of each person is at the time he/she was a member.

TEAM SPONSOR

DARRELL ZASTROW – Forestry (retired)

101 South Webster
P.O. Box 7921 (mailing address)
Madison WI 53707
(608) 266-0290

CURRENT MEMBERS

JERRY BARTELT – Science Services (retired)

Member 1997–present
Team Leader 2001–present
4744 Old Indian Trail
Black Earth, WI 53515

OWEN BOYLE – Natural Heritage Conservation

Member 2005–present
101 South Webster
P.O. Box 7921 (mailing address)
Madison WI 53707
Owen.Boyle@wisconsin.gov

ERIC EPSTEIN – Endangered Resources (retired)

Member 1999–present
22505 Kensington Road
Norwalk, WI 54648

DREW FELDKIRCHNER – Natural Heritage Conservation

Member 2007–present
101 South Webster
P.O. Box 7921 (mailing address)
Madison WI 53707
(608) 266-2196
Drew.Feldkirchner@wisconsin.gov

LISA HELMUTH – Watershed Management

Member 2008–present
101 South Webster
P.O. Box 7921 (mailing address)
Madison WI 53707
(608) 266-7768
Lisa.Helmuth@wisconsin.gov

SCOTT HULL – Science Services

Member 2010–present
2801 Progress Drive
Madison WI 53716
608-224-6196
Scott.Hull@wisconsin.gov

JEFF SCHIMPF – Environmental Analysis and Sustainability (retired)

Member 2002–present
101 South Webster
P.O. Box 7921 (mailing address)
Madison WI 53707
(608) 267-7853

ANDY STOLTMAN – Forestry

Member 2004–present
101 South Webster
P.O. Box 7921 (mailing address)
Madison WI 53707
Andrew.Stoltman@wisconsin.gov

PREVIOUS TEAM SPONSORS

SARAH SHAPIRO HURLEY – Administration (retired)

CHARLES HIGGS – Forestry (retired)

KARL MARTIN – Science Services

(now at University of Wisconsin Extension-Madison)

PREVIOUS TEAM MEMBERS

MIKE BEAUFEAUX (retired)

Member 1997–2000
Forestry – Northern Region

SUSAN BERGQUIST (deceased)

Member 1998–2000
Watershed Management

CATHY BLESER (retired)

Member 1997–1998, 2010–2014
Endangered Resources

VERN EVERSON (retired)

Member 2000–2014
Forestry

SHANNON FENNER

Member 2001–2002
Science Services

DIANE FIGIEL

Member 2001–2002
Watershed Management

SIGNE HOLTZ (retired)

Team Leader 1997–1999
Endangered Resources

SARAH SHAPIRO HURLEY (retired)

Member 1997–1998
Wildlife Management

PREVIOUS TEAM MEMBERS, continued

CHUCK LEDIN

Member 1997
Watershed Management

JODY LES (retired)

Member 1997–2000
Facilities and Lands

COLLEEN MATULA

Member 2001–2007
Forestry – Northern Region

EUNICE PADLEY

Member 2001–2010
Forestry and Science Services (now at Natural Resources
Conservation Service, Washington D.C.)

REBECCA (ISENRING) SCHROEDER (retired)

Member 1998–1999
Team Leader 1999–2001
Endangered Resources

BILL VANDER ZOUWEN (retired)

Member 1997–2001
Wildlife Management

PETE WOLTER

Member 2003–2007
Facilities and Lands – West Central Region

DARRELL ZASTROW (retired)

Member 1997–2001
Forestry

OTHER CONTRIBUTORS TO THE WORK OF THE ECOSYSTEM MANAGEMENT PLANNING TEAM

KATE BARRETT – Maps

JULIE BLESER – Data and maps

SALLY DAHIR – Data and maps

LOLA DVORAK – Writing and editing

LYNN ENTINE – Writing and editing

TRISHA GOODWEILER – Team administration

KATHY HANSON – Maps/book materials

SARAH HERRICK – Photo organization/editing

NINA JANICKI – Maps

JESCIE KITCHELL – Socioeconomic analyses and book
materials

BARBARA MARTINEZ – Book materials

MITCH MOLINE – Maps

JEFF PREY – Recreation information

BILL SHOCKLEY – Maps

JENNIFER SKOLODA – Maps/editing

ELIZABETH SPENCER – Background materials

STACEY YUDS – Publication distribution



Appendix B. Abbreviations Used in the Book

AOC – Area of Concern	MCL – Maximum contaminant level
ASR – Aquifer storage and recovery	MFL – Managed Forest Law
BCA – Bird Conservation Area	mIBI – Macroinvertebrate-based index of biological integrity
BEACH – Beaches Environmental Assessment and Coastal Health Act	MRBI – Mississippi River Basin Healthy Watersheds Initiative
BMPs – Best Management Practices	NABCI – North American Bird Conservation Initiative
BOD – Biological Oxygen Demand	NERR – National Estuarine Research Reserve
CCC – Civilian Conservation Corps	NGO – Nongovernmental Organization
COA – Conservation Opportunity Area	NHFEU – National Hierarchical Framework of Ecological Units
CREP – Conservation Reserve Enhancement Program	NHI – Natural Heritage Inventory
CRP – Conservation Reserve Program	NLCD – National Land Cover Database
CSA – Community Supported Agriculture	NOAA – National Oceanic and Atmospheric Administration
CWD – Chronic wasting disease	NPS – National Park Service
CWMA – Cooperative Weed Management Area	NRCS – Natural Resources Conservation Service
DDT – Dichlorodiphenyltrichloroethane	NRDA – Natural Resources Damage Assessment
DDD – Dichlorodiphenyldichloroethane	NRI – Natural Resources Inventory
DDE – Dichlorodiphenyldichloroethylene	NWS – National Weather Service
DRUMS – Determination of Rights and Unity for Menominee Shareholders	ORW – Outstanding Resource Waters
EDC – Endocrine-disrupting chemicals	PAH – Polycyclic aromatic hydrocarbon
EMPT – Ecosystem Management Planning Team	PBT – Persistent bioaccumulative toxins
EO – Element occurrence	PCB – Polychlorinated biphenyl
EQIP – Environmental Quality Improvement Program	PCP – Personal care product
ERW – Exceptional Resource Waters	PIF – Partners in Flight
FERC – Federal Energy Regulatory Commission	PLS – Public land survey conducted by the federal General Land Office
FHTCS – Forest habitat type classification system	RAP – Remedial Action Plan
FIA – Forest Inventory and Analysis	RIV – Relative importance value
fIBI – Fish Index of Biotic Integrity	ROW – Register of Waterbodies
FPL – U.S. Department of Agriculture Forest Products Laboratory	SAFE – State Acres for Wildlife Enhancement
FSC – Forest Stewardship Council	SAMP – Special Area Management Plan
GAA – Groundwater Attention Area	SCORP – Statewide Comprehensive Outdoor Recreation Plan
GIS – Geographic Information System	SEWRPC – Southeastern Wisconsin Regional Planning Commission
GLC – Great Lakes Commission	SFI – Sustainable Forestry Initiative
GLIFWC – Great Lakes Indian Fish and Wildlife Commission	SGCN – Species of Greatest Conservation Need
GLO – Federal General Land Office	SNA – State natural area
GLRI – Great Lakes Restoration Initiative	STATSGO – State Soils Geographic Database
GPA – Groundwater protection area	SWGSCA – Southwest Wisconsin Grasslands and Streams Conservation Area
HCP – Habitat Conservation Plan	SWIMS – Surface Water Integrated Monitoring System
HEL – Highly erodible land	SWP – Source water protection program
HR – Habitat rating	TFM – 3-trifluoromethyl-4-nitrophenol
IBA – Important Bird Area	TMDL – Total Maximum Daily Load
IBI – Index of biotic integrity	TNC – The Nature Conservancy
ICPSR – Inter-university Consortium for Political and Social Research	TRM – Targeted runoff management
IMPLAN – Impact analysis for Planning	TSI – Carlson's trophic state index
LaMP – Lakewide Management Plan	UMRBA – Upper Mississippi River Basin Association
LIP – Landowner Incentive Program	USACE – U.S. Army Corps of Engineers
LQ – Location quotient	USBEA – United States Bureau of Economic Analysis
LTA – Landtype Association	USCB – U.S. Census Bureau
LTRMP – Long Term Resource Monitoring Program	USDA – U.S. Department of Agriculture

USDA ERS – U.S. Department of Agriculture's Economic Research Service
USEPA – U.S. Environmental Protection Agency
USFS – U.S. Forest Service
USFWS – U.S. Fish and Wildlife Service
VHS – Viral hemorrhagic speticemia
VOC – Volatile organic compound
WAPIT – Wisconsin Wildlife Action Plan Implementation Team
WASS – Wisconsin Agricultural Statistics Service
WATERS – Waterbody Assessment Tracking and Electronic Reporting System
WBCI – Wisconsin Bird Conservation Initiative
WDACP – Wildlife Damage Abatement and Claims program
WDATCP – Wisconsin Department of Agriculture, Trade, and Consumer Protection

WDNR – Wisconsin Department of Natural Resources
WHIP – Wildlife Habitat Improvement Program
WHP – Wellhead protection plan
WICCI – Wisconsin Initiative on Climate Change Impacts
WisCALM – Wisconsin Consolidated Assessment and Listing Methodology
WISCLAND – Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data
WNS – White-nose syndrome
WPDES – Wisconsin Pollutant Discharge Elimination System
WPHRA – Western Prairie Habitat Restoration Area
WQA – Water Quality Agreement
WWAP – Wisconsin Wildlife Action Plan
WWI – Wisconsin Wetland Inventory



Appendix C. Data Sources Used in the Book

This section lists the electronic data sets used in this publication, discusses briefly why each data set was chosen to aid in describing the ecological landscapes, points out some of the strengths and weaknesses of each data set, and directs the reader to where more information can be found that further describes these data sources. This section is not intended as metadata for the publication; rather it is meant to help understand how data sets were used in this analysis. For additional information that can be used to plan ecosystem management, see “Information Sources Helpful to the Ecosystem Management Planning Process” in Chapter 1, “Principles of Ecosystem and Landscape-scale Management.”

Naming Conventions

For all species, the scientific name is parenthetically listed in italics after the first occurrence of the common name in the main body of the text in each chapter. After that, only the common name is used. An appendix of all common and scientific names used follows each chapter in Part 1, and Appendix J is a table of all common and scientific names used in each ecological landscape chapter.

For both the scientific and common names of birds, we used the American Ornithologists Union Checklist of North America Birds (<http://www.aou.org/>). For animals listed as Wisconsin Endangered, Threatened, or Special Concern, we used the Wisconsin DNR Natural Heritage Inventory (NHI) Working List for both scientific and common names. For more common mammals that do not occur on the Working List, we used Wisconsin DNR Miscellaneous Publication PUB-SS-1089 2011, *Current Scientific and Standard Common Names of Wisconsin Mammals* (<http://dnr.wi.gov/files/PDF/pubs/ss/SS1089.pdf>). For plants, we used the Wisconsin State Herbarium WISFLORA: Wisconsin Vascular Plant Species (<http://www.botany.wisc.edu/herbarium/>) for both scientific and common names. The capitalization conventions for common names come from those particular sources.

Throughout this document, the NHI natural community names are capitalized. Occasionally, these communities are discussed generically, and in those cases the names are not capitalized (e.g. the use of the “Northern Sedge Meadow” natural community is capitalized, but when speaking more generally about “sedge meadows,” it is not).

Past Land Cover

Data sets that help to analyze historical land cover of Wisconsin are not numerous. The most commonly used data source for vegetation from the mid-1800s comes from the federal General Land Office’s public land survey (PLS) that was conducted over a 34-year period from 1832 through 1866. An excellent source that details the methods, uses, and limitations

of the PLS data is “The Original US Public Land Survey Records” by Schulte and Mladenoff (2001).

There have also been interpretations of these data, most notably by Finley (1976). Robert W. Finley, Professor of Geography Emeritus of the University of Wisconsin, created a map of natural community types for Wisconsin based on the PLS witness tree points as well as the surveyor notes of the areas being surveyed. Finley’s map has since been digitized for use in GIS.

In conjunction with the Wisconsin Department of Natural Resources, researchers from the University of Wisconsin created a GIS point coverage from the original PLS notes (He et al. 2000). This coverage included spatial information about each witness tree, its species, diameter at breast height (DBH), and distance from the section corner post. For this publication, we used this point coverage to calculate a relative importance value (RIV) for tree species and species groups. The methods for this analysis can be found in “GIS Interpolations of Witness Tree Records (1839–1866) for Northern Wisconsin at Multiple Scales” (He et al. 2000). The original survey notes were also consulted to assess the general conditions of specific areas.

Recent Land Cover

There are several data sets available to assess current land cover at broad scales in Wisconsin. Each was developed for slightly different purposes and has its own strengths and weaknesses. We used WISCLAND (vegetation types interpreted from satellite imagery in 1992) for land use classifications (e.g., forests, grassland, agriculture, urban), and National Land Cover Data (NLCD) to obtain an estimate of impervious surfaces within an ecological landscape. Forest Inventory and Analysis (FIA) data, based on sample plots throughout the state, were used to estimate current tree species composition and abundance within an ecological landscape. “Timberland” data, based on FIA data, are used in the socioeconomic sections of the chapters since that is how forest products information is summarized. “Timberland” is defined as forestland that is producing or is capable of producing more than 20 cubic feet per acre per year of industrial wood crops under natural conditions, that is not withdrawn from timber utilization, and is not associated with urban or rural development. Wisconsin Wetlands Inventory (WWI) data were used to estimate the number and acres of wetlands as well as to characterize the types of wetlands (e.g., forested, marsh, meadow) within an ecological landscape. The percent of surface water within an ecological landscape is estimated from WISCLAND. The number and acreage of lakes and the number and miles of streams were determined using county Surface Water Inventory data. The percentage of public land ownership is derived from several sources, including data provided by the state, individual counties, and the federal

government. On occasion, these data offer slightly different estimates for vegetation and land cover as a result of differing methodologies and data sources. In general, we have cited the information from those data sets that are most appropriate for the specific factor being discussed. More detailed descriptions of these data sets are found below.

WISCLAND

Formed in 1993, “WISCLAND” is the Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data, a partnership of public and private organizations seeking to facilitate landscape GIS data development and analysis. The WISCLAND consortium was instrumental in the funding and implementing a five-year work effort to interpret the state’s land cover from satellite images. An update to the original database, called WISCLAND 2.0, was completed and became available in August 2016.

The WISCLAND land cover data used in this publication are derived primarily from 1992 satellite imagery. After processing, the data have a minimum mapping unit of 5 acres, meaning that most land cover features 5 acres or larger can be determined from the data. The classified land cover types can be summarized to indicate how much of each land cover is present over large areas of interest, such as ecological landscapes.

WISCLAND data are classified into a three-level hierarchy, from more general classes to more specific subclasses. For example, a pixel classified as “4” is “Forest,” as “4.1” it is “Coniferous Forest,” and as “4.1.1” it is “Jack Pine Forest.” The more general classes have less error associated with them.

Although it does not represent present day information, we used it in the publication to offer a general view of land use and land cover for each ecological landscape. For more information about WISCLAND, including metadata, see <http://www.dnr.state.wi.us/maps/gis/data/landcover.html> or <http://www.sco.wisc.edu>, keyword “WISCLAND.”

Forest Inventory and Analysis Data

Forest Inventory and Analysis (FIA) data (U.S. Forest Service 2004) are compiled point samples of forested lands used to assess U.S. timber resources. The FIA data contain more detailed information on forest types and species compositions than WISCLAND and can be generalized across ecological landscapes. Because FIA data are derived from on the ground sampling, as opposed to satellite imagery, they may offer a different interpretation of forests than WISCLAND.

For the ecological sections of the chapters, FIA data from 2004 were summarized and used for assessment. For the socioeconomic sections, FIA data from 2007 and 2009 were summarized and used. Therefore there may be slight difference between the estimates in the ecological and socioeconomic sections of the chapters due to different data sources. For more information about the FIA program, methods, and data including metadata, see <https://www.fia.fs.fed.us>.

Wisconsin Wetlands Inventory

To assess wetlands, the Wisconsin Wetlands Inventory (WWI) was used. WWI was originally established in 1978 with a stated purpose to protect wetlands. The initial inventory was completed in 1984, prepared from the analysis of high altitude aerial imagery in conjunction with soil surveys, topographic maps, previous wetland inventories, and field work. In more recent years, the inventory has been updated with newer remotely sensed imagery and other data. At the time of this analysis, eight counties had yet to be updated, including Chippewa, Dunn, Eau Claire, Florence, Forest, Jackson, La Crosse and Vilas counties. For the analyses in this publication, the newer data on wetlands were used, except for the eight counties that were not yet completed, where the original data from 1984 were used. For more information about WWI, including metadata, see <http://dnr.wi.gov>, keywords “Wisconsin Wetland Inventory.”

Forest Habitat Types

Forest Habitat Types provide an estimate of forest site quality and potential vegetative communities, which is used by many foresters. Forest Habitat Types are site classifications based on the composition of understory vegetation. This system operates independently from current overstory composition but represents the potential vegetation at maturity of sites with similar characteristics (Kotar and Burger 1996, Kotar et al. 2002). Habitat type data were collected at plots throughout Wisconsin in conjunction with the FIA program (Forest Inventory and Analysis, U.S. Forest Service).

Land Type Associations

Land Type Association (LTA) information depicts ecological units at a more detailed scale than ecological landscapes and is referenced in the publication when it is useful for understanding local ecological information or local planning. LTA information was developed according to the classification scheme of the National Hierarchical Framework of Ecological Units (NHFEU) (Cleland et al. 1997). The NHFEU is an ecological classification system that divides landscapes into ecologically significant regions at multiple scales on the associations of biotic and environmental factors, including climate, physiography, water, soils, air, hydrology, and potential natural communities. LTAs were developed, mapped, and described in participation with a variety of agencies, organizations, and individuals.

Surface Water Data Viewer

Much of the information presented in the hydrology section of each chapter was gathered using the Surface Water Data Viewer. The Surface Water Data Viewer is a publicly accessible mapping application that provides water resources, monitoring, and water quality assessment data. Users may view and analyze a wide variety of watershed-related data by geographic

areas including ecological landscapes, counties, or water management units. Data sets are updated as frequently as possible, and new data layers are added periodically as new needs are identified. Data sets available are grouped within the general categories of Hydrologic Units; Fisheries Management Waters; Lakes and Streams; Dam and Floodplain Management; Aquatic Invasives; Water Quality Monitoring and Assessment (including 303d impaired waters and Outstanding/Exceptional Resource Waters); Wetlands, Plants and Habitat; Permit Data (including navigability); and Water Grants Programs. For more information about the Surface Water Data Viewer, see <http://dnr.wi.gov>, keywords “Surface Water Data Viewer.”

Natural Heritage Inventory

The Wisconsin Natural Heritage Inventory (NHI) program is part of the Wisconsin DNR’s Bureau of Natural Heritage Conservation and a member of an international network of Natural Heritage programs representing all 50 states as well as portions of Canada, Latin America, and the Caribbean. These programs share standardized methods for collecting, processing, and managing data for rare species and natural communities. NatureServe, an international nonprofit organization, coordinates the network. See www.NatureServe.org for more information on the NatureServe Network as well as data standards and methods.

Natural Heritage programs track certain occurrences of biological diversity, rare plants, rare animals, high-quality examples of natural communities, and other select natural features. The NHI Working List contains the Elements tracked in Wisconsin including Endangered, Threatened, and Special Concern plants and animals as well as the natural community types recognized by NHI. The NHI Working List is periodically updated to reflect new information about the rarity and distribution of the state’s plants, animals, and natural communities. The NHI Working List from November 2009 was used for this publication. The most recent NHI Working List is available from the Wisconsin DNR website (see <http://dnr.wi.gov>, keywords “Working List”).

The Wisconsin NHI database stores locational information for documented occurrences of the Elements on the NHI Working List. Data attributes are stored in both spatial and tabular formats. NHI data are exempt from Wisconsin’s Open Records Law due to the vulnerability of rare species to collection and destruction, and use of NHI data requires a formal data license agreement in accordance with Wis. Stats. 23.27 and NR 29.04.

The NHI database is the most comprehensive source of locations for Wisconsin’s rare species and high-quality examples of natural communities. However, most of the state has not been thoroughly and systematically surveyed. As a result, a lack of occurrences for a particular area does not imply that there are no rare species present. Second, the presence of one Element does not imply that a survey was conducted for other Elements in the area. Finally, some NHI records are considered historic (pre-1970) and have not been confirmed since that time.

Statewide Comprehensive Outdoor Recreation Plan (SCORP)

Many factors affect the supply, demand, and participation rates of outdoor recreation in Wisconsin. Since 1965 the state has developed and maintained the Statewide Comprehensive Outdoor Recreation Plan (SCORP) in an attempt to classify, measure, and provide for the preferences and needs of a statewide recreating public. The SCORP plan is done every five years to identify essential issues that affect the future of Wisconsin outdoor recreation and includes appropriate recommendations. Data from the 2005–2010 SCORP report were used in this publication.

The SCORP examines and assesses current and future recreational needs within the state. To aid in this process, Wisconsin was divided into a group of eight planning regions, each representing a loose collection of natural resource and tourism based assets. For more information about the SCORP, see see <http://dnr.wi.gov>, keyword “SCORP”).

U.S. Census Bureau

The U.S. Census Bureau serves as the leading source of quality data about the nation’s people and economy. More than just numbers, this information shapes important policy decisions that help improve the nation’s social and economic conditions. Various data sets from the Census Bureau were used in the socioeconomic sections of the chapters.

Demographic

The U.S. Census Bureau conducts household and institutional surveys, many of which are sponsored by other federal agencies. Information from these surveys is used to measure income, poverty, education, health insurance coverage, housing quality, crime victimization, computer usage, and scores of other subjects that are vital to understanding the people of the United States. The Census Bureau also supplies data that are the basis for the U.S. Bureau of Labor Statistics’ monthly unemployment rate and the Consumer Price Index.

Economic

Monthly, quarterly, and annual surveys provide information on the current state of the economy. Census Bureau economic surveys provide a majority of the information the Bureau of Economic Analysis uses to update the Gross Domestic Product, data used by the Bureau of Labor Statistics in reporting monthly Producer Price Index changes, and data used by the Federal Reserve Board as input to indices of industrial production and capacity utilization.

County Business Patterns

The County Business Patterns report is an annual series that provides sub-national (regional) economic data by industry. The series is useful for studying the economic activity of small areas; analyzing economic changes over time; and as a benchmark for statistical series, surveys, and databases between

economic censuses. Businesses use the data for analyzing market potential, measuring the effectiveness of sales and advertising programs, setting sales quotas, and developing budgets. Government agencies use the data for administration and planning. County Business Patterns data were used in this publication to determine the important economic sectors in each ecological landscape.

County Business Patterns cover most of the country's economic activity. The series excludes data on self-employed individuals, employees of private households, railroad employees, agricultural production employees, and most government employees.

This series has been published annually since 1964 and at irregular intervals dating back to 1946. The comparability of data over time may be affected by definitional changes in establishments, activity status, and industrial classifications. For more details on County Business Patterns, see <https://www.census.gov>, keywords "county business patterns."

National Agriculture Statistical Service

The U.S. Department of Agriculture's National Agricultural Statistics Service (NASS) conducts hundreds of surveys every year and prepares reports covering virtually every aspect of U.S. agriculture. Production and supplies of food and fiber, prices paid and received by farmers, farm labor and wages, farm finances, chemical use, and changes in the demographics of U.S. producers are only a few examples. NASS data were used in this publication to describe the characteristics of agriculture in each ecological landscape.

NASS provides timely, accurate, and useful statistics to U.S. agriculture. Some of the services provided by NASS include:

- Reports on the facts on American agriculture, facts needed by people working in and depending upon U.S. agriculture.
- Objective and unbiased statistics on a preannounced schedule that is fair and impartial to all market participants.
- A Census of Agriculture every five years, providing the only source of consistent, comparable, and detailed agricultural data for every county in America.
- Serves the needs of data users and customers at a local level through a network of State field offices and cooperative relationships with universities and State Departments of Agriculture.
- Privacy to farmers, ranchers, and other data providers, with a guarantee that confidentiality and data security continue to be top priorities.

For more information about the NASS, see <https://www.nass.usda.gov>.

Literature Cited

- Cleland, D.T., P.E. Avers, W.H. McNab, M.E. Jensen, R.G. Bailey, T. King, and W.E. Russell. 1997. National hierarchical framework of ecological units. Pages 181–200 in M.S. Boyce and A. Haney, editors. 1997. *Ecosystem management: applications for sustainable forest and wildlife resources*. Yale University Press, New Haven, Connecticut.
- Finley, R. 1976. *Original vegetation of Wisconsin*. Map compiled from U.S. General Land Office notes. U.S. Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota.
- He, H.S., D.J. Mladenoff, T.A. Sickley, and G. G. Guntenspergen. 2000. GIS interpolations of witness tree records (1839–1866) for northern Wisconsin at multiple scales. *Journal of Biogeography* 27:1031–1042.
- Kotar, J., and T.L. Burger. 1996. *A guide to forest communities and habitat types of southern Wisconsin*. University of Wisconsin-Madison, Department of Forestry, Madison.
- Kotar, J., J.A. Kovach, and T.L. Burger. 2002. *A guide to forest communities and habitat types of northern Wisconsin*. Second edition. University of Wisconsin-Madison, Department of Forest Ecology and Management, Madison.
- Schulte, L. A., and D. J. Mladenoff. 2001. The original U.S. public land survey records: their use and limitations in reconstructing presettlement vegetation. *Journal of Forestry* 99:5–10.
- U.S. Forest Service. 2004. Forest Inventory and Analysis, Mapmaker, Version 1.0. (Note: USFS has discontinued the Forest Inventory and Analysis Mapmaker program. See the U.S. Forest Service's "Tools and Applications" web page, <http://www.nrs.fs.fed.us/tools/software/>.)



Appendix D. Descriptions of Ecosystem Management Concepts

Scale

Scale, both across space (spatial) and time (temporal), is one of the most important concepts in ecosystem management. Management and planning of natural resources should consider resources from the smallest management units, such as “stands” often used by foresters, all the way to ecological landscapes, multi-state regions, and beyond. Some natural communities or special microhabitats can only be defined at the finest scales and may not be easy to track using common mapping tools such as forest stands or GIS applications. Conversely, some resources can only be addressed at much broader scales including state, regional, continental, or even global scales. For example, the regional decline of red and white oak forests can be mediated by local management, but only if many local managers work together to reverse the broad-scale trend of decline.

Temporal scales are important for ecosystem management, as ecosystems are never static and are constantly changing. These changes are important to consider, even when they occur slowly. For some ecosystems, such as forests, the time required for major changes can exceed a human lifetime. For these long-term changes, we often have to infer from other ecosystems or other time periods for planning purposes. Sometimes information from a time period prior to Euro-American settlement is used for this purpose.

Cumulative effects of management are often not well understood. However, the cumulative impacts of our activities to species and communities, both spatially and temporally, are important to consider for effective ecosystem management.

Landscape Ecology

Landscape ecology is the science of the relationship between spatial pattern and ecological processes across a range of scales (Turner et al. 2001), and it provides numerous tools for ecosystem management. One important concept related to ecosystem management is that, in addition to the size and many other characteristics of a given area, it is important to consider how the area is related to other patches of habitat in the surrounding landscape, as well as the spatial arrangement of all of the collective patches. Landscapes, the patterns studied by landscape ecology, can be characterized at different scales, depending on the attributes being studied. This publication focuses on ecological landscapes. They are broad areas delineated from physical and biological characteristics such as climate, geology, soils, water, or vegetation, but other units of differing sizes could be necessary, depending on the situation.

Biodiversity

Biodiversity is the variation of life forms within a given ecosystem, biome, or on the entire planet and is often used as a measure of the “health” of biological systems. Biodiversity can occur from the genetic level to the species, community, and ecosystem levels. Maintaining or improving biological diversity is part of an ecological approach toward maintaining functional ecosystems. Activities that improve biological diversity will vary depending on the ecosystem: the mix, relative abundance, and patch sizes of vegetative communities should always be considered relative to natural disturbance regimes and historic vegetation.

Biological diversity can be difficult to quantify. The total number of species in an area, species richness, is a poor measure of biological diversity because generalist, weedy, or invasive species are included. Such species may be harmful to less common species and would not usually be considered beneficial for biological diversity. Also, certain species that do not share the habitat preferences of the majority may be consistently left out using this approach. Therefore, striving for biodiversity on a single site, although historically a common management goal, is not often the best approach if all of the species and habitats are to be maintained somewhere in the state.

To adequately assess biodiversity and include the entire suite of species in Wisconsin’s flora and fauna, it is important to work at different scales including broad assessments at the landscape or regional level. When a site supports scarce or sensitive species, it tends to have a higher conservation value, as these features are likely missing from most other sites. A thorough assessment of biodiversity at a broad scale would include all of these high conservation value sites, along with other types of managed areas. This would help determine the need for a particular type of management within a given area or at least provide a better understanding of how planned or ongoing management might contribute to the overall biodiversity goals for the landscape.

Ecological Context

Ecological context is important because areas of land or water are often strongly influenced by the ecology and use of the areas surrounding them. For some species, the surrounding landscape may be more important than local site conditions (Rogers et al. 2009). Considerations of context when planning management may be critical in determining the success or failure of management outcomes, especially for the more sensitive or specialized organisms, and for habitats that may be susceptible to colonization by invasive species. When possible

and where appropriate, naturally co-occurring complexes of communities should be planned and managed together. See the “Conservation Design” section in Chapter 1 for examples.

Ecosystem Function

Ecosystem functions are the collection of natural processes that sustain an ecosystem and its components. For example, periodic flooding shapes and maintains floodplain forest ecosystems. Management that takes advantage of, or mimics, naturally occurring ecosystem functions may be more cost effective and successful over the long-term. For example, managing for grasslands in a formerly forested area could result in expensive brush control compared to managing grasslands in a former prairie area. Disruption of a natural disturbance regime can affect the composition and structure of vegetation and other habitat features. For example, the suppression of fires can be expected to cause native grasslands such as prairies to succeed or convert to shrub or forest habitats.

Community Composition and Structure

Natural community composition and structure includes the species present in the community as well as the vertical and horizontal vegetative structure of the community. For example, in a forest community it would include all the plant species that comprise the community as well as the structure provided by the herb layer, shrub layer, understory trees, and canopy trees. Horizontal structure includes the size, shape, connectivity, and ecological context of the community.

Both structure and composition are very important to providing habitat for some species and change over time through succession or development. Some plants (e.g., those adapted to periodic wildfire) and wildlife species, especially many bird species, respond to community structure more than to composition, and some birds that are habitat specialists are quite exacting in the structures that constitute acceptable habitat, including both vertical and horizontal structure. Other species groups, such as some prairie invertebrates, require particular plant species to complete their life cycle. Often structures such as very large trees, tree cavities, and dead and downed logs in forests are missing from communities. Management could include provisions for restoring these features wherever possible.

A Range of Age Classes and Patch Sizes

Some species are associated with specific seral stages. Management of natural resources should consider and encompass different seral stages, developmental stages (ages), patch sizes, linkages, and key ecotones associated with and representative of a given community type. Management for a narrow range of potential age classes or patch sizes simplifies the overall ecosystem and can compromise ecological function or limit habitat for some species. In many areas certain age classes or developmental stages are lacking, such as the lack of older and old-growth forests in Wisconsin. Representation of a range of age classes and patch sizes for each community type within a given ecological landscape, as well as their shape and spatial

distribution, are important considerations for ecosystem planning and management.

Dispersal

Dispersal and the interchange of individuals and flow of genetic material between populations is important for maintaining sustainable species populations, and it can be disrupted in a number of ways. The ability to disperse varies among species and patches of fragmented habitat can become so isolated and separated by distance and unfavorable habitat that dispersal is not possible for some species. Barriers such as roads, dams, and cities prevent movement of some species.

Corridors and Connectivity of Habitats

Corridors and connectivity of habitats can support the dispersal and migration of species that must move under certain conditions or at certain times of the year. Connectivity among community types and across ecotones should be considered when planning conservation projects and management. Linking aquatic habitats with upland habitats is critical for species that utilize both terrestrial and wetland or aquatic habitats during their life cycles. In addition, opportunities for connectivity between large blocks of habitat should be identified and considered in state, regional, and local management and protection plans. Travel and dispersal corridors for plants and animals are likely to become increasingly important as fragmentation of habitats becomes more widespread and severe and as global climate change causes the ranges of species and habitats to shift. Removal of dams can restore connectivity of aquatic habitats, although there are additional considerations including providing a means of entry for undesirable species such as invasive plants and animals.

Habitat Specialists and Generalists

Habitat specialists and habitat generalists both occur in Wisconsin. Some species have very narrow and specific habitat requirements, while others are adapted to a much broader range of habitat conditions. Species that require highly specialized habitats are usually less abundant and at greater risk of decline. Species that can survive in a number of more common habitats usually are more abundant and secure. Management should ensure that habitat specialists, especially those that are well represented in Wisconsin, are accommodated when possible as part of a broad landscape-scale strategy. Management to increase habitat generalists at the expense of species requiring specialized habitats should be avoided to maintain the state's biodiversity.

Edge of Range Species

Many species reach their geographic range limits in Wisconsin, including a number of rare species. To determine management priorities for such species, their status and population trends beyond Wisconsin's borders should be considered. However, state laws and, sometimes, current management direction can constrain actions.

Keystone Species

Keystone species have significant impacts on the composition and structure of their habitats relative to their abundance or total biomass. Keystone species should be managed carefully to prevent unwanted ecological changes. For example, long periods of heavy browse by large white-tailed deer populations can change the species composition and structure of Wisconsin's forests, eliminating browse-sensitive plant species, and simplifying the herbaceous layer used by ground-nesting birds and other organisms. Similar impacts have been reported in numerous parts of the eastern U.S. Excessive browse by white-tailed deer has become a significant concern for the regeneration of important forest plants, including dominant trees such as eastern hemlock, northern white-cedar, yellow birch, and northern red oak. Reduction of the overall productivity of northern forests because of excessive browse pressure has become a concern (Wisconsin Council on Forestry 2005).

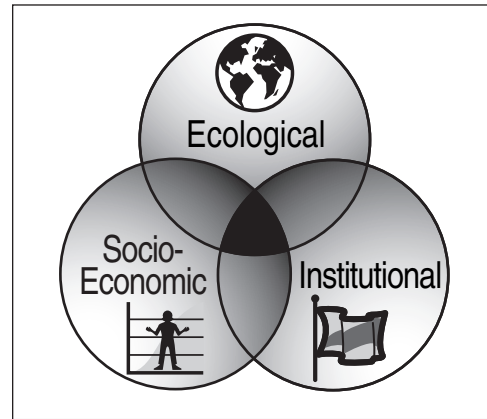
Social Considerations

Social considerations in ecosystem management include historical background, people's perceptions about resource values, existing social conditions, societal needs and demands, and the effects of humans on ecosystems. Resource management decisions have direct and indirect impacts on social well-being at the local, regional, and state levels, as well as on current and future human needs.

Societal goals are often broad and not particularly well defined. Policies of the Wisconsin Environmental Policy Act (Wisconsin Environmental Policy Act, Wis. Stat. § 1.12, and Wis. Adm. Code NR 150, 1972) include "stimulate the health and welfare of man," and "assure safe, healthful, productive, and aesthetically and culturally pleasing surroundings." The Public Forests Act (Wisconsin Act 257, 1995) describes the contribution of state forests to a healthy environment, protection of water quality, production of recurring forest products, outdoor recreation, and aesthetics. It further notes that the range of benefits from a state forest "shall reflect its unique character and position in the regional landscape." When the Wisconsin DNR proposes new Administrative Rules, Wisconsin Act 118 requires an analysis of economic costs that the private sector would incur in complying with the rule. The DNR's mission statement speaks to outdoor opportunities, the use and enjoyment of natural resources, understanding the wishes of the public, and maintaining options for future generations. Public lands can provide recreational opportunities as well as economic products that are not readily available within the private sector. However, use of economic products from public lands should be done sustainably and with consideration of other ecological and landscape-scale needs for future generations.

Management Decision-Making

The Wisconsin DNR's ecosystem management decision model includes ecological, social, and institutional considerations (WDNR 1995). The goal is to promote management that provides benefits to all three of these factors. The diagram



graphically shows this approach to decision-making. The area overlapping in the center is management that best promotes ecosystem management.

Ecological Restoration

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (SER 2004). Ecological restoration can sometimes partially compensate for human-caused negative habitat impacts (e.g., wetland mitigation) and provide surrogate habitat for some species. Ecological restoration efforts can be an important part of maintaining biodiversity, especially for very rare natural communities or for those that rely on a form of disturbance that is now largely unavailable (e.g., fire adapted communities). However, the created habitat usually cannot fully replace what was lost because some ecosystem components and functions are likely missing and the surrounding ecological context may have changed.

Ecological Simplification or Ecological Homogenization

Ecological simplification means the interrelationships between organisms and their environments are reduced in number and complexity (WDNR 1995). Simplification causes a reduction in biological diversity and functioning of an ecosystem. When an ecosystem loses species or groups of species with a resulting simplified system, biodiversity is diminished. In addition, when ecosystems are simplified they usually are less stable and ecological function may be compromised.

Homogenization occurs when a landscape is managed to have the same species and age classes everywhere. Homogenization eliminates or prevents diverse communities from forming to support a variety of species and adapt to changing conditions. It also puts the managed community at greater risk for emerging diseases, insects, and climate change.

Habitat Loss

The direct loss (destruction) of habitat has been ongoing since Euro-American settlement and continues today. Habitat loss is

a major threat to plant and animal species. It causes declines in the numbers of a particular species as well as the loss of species themselves from some areas of the state. Extreme habitat loss can result in the extirpation of a species from an area or even extinction.

Habitat Alteration

Habitat alteration changes the composition, structure, or function of a natural community by any number of means, including logging, disrupting hydrology, suppressing or promoting fire (depending on the natural disturbance regime), disease, or encroachment by invasive species. The impacts may be negative, positive, or neutral and may vary with time. For example, cutting an old-growth forest and maintaining it in an early succession stage (this is the normal condition in Wisconsin's present northern forests, where formerly abundant old-growth stands are now virtually absent) or flooding a sedge meadow to create a deep water marsh alters habitat and results in the establishment of a different plant community. Care must be taken to ensure that habitat specialist species are not harmed in the process or that sufficient areas are maintained to protect these species.

Habitat Conversion

Habitat conversion changes the structure, composition, and function of one ecosystem to something completely different. The intent of such conversions is often to increase production of one or several desired species for economic or recreational reasons. Common examples in Wisconsin include the conversion of prairie to agricultural cropland, the conversion of oak and pine barrens to monotypic pine plantations, and the conversion of sedge meadows, shrub swamps, bogs, fens, and even floodplain forest to marshes.

Habitat Fragmentation

Habitat fragmentation occurs when large patches of relatively homogeneous habitat are broken into smaller fragments of habitat separated by dissimilar land uses, resulting in smaller patches and more edge. Species that are adapted to large

patches of "interior" habitat (which can be forest, grassland, wetland, or something else) may decline or disappear. Some area-sensitive species will only breed successfully in large, unbroken patches of habitat such as Upland Sandpiper and many of the wood warblers. Generalists often do well in more fragmented habitats. In some portions of the state, unfragmented habitats have become quite rare.

Habitat Isolation

Habitat isolation occurs when a patch of one type of habitat is surrounded by dissimilar habitat, such as a woodlot in a matrix of agricultural fields or a patch of old-growth forest surrounded by early successional forest. When fragmentation within a landscape becomes severe, the habitat is ultimately isolated and the ability of that habitat patch to retain its characteristic complement of species often declines.

Literature Cited

- Rogers, D.A., T.P. Rooney, T.J. Hawbaker, V.C. Radeloff and D.M. Waller. 2009. Paying the extinction debt in southern Wisconsin forest understories. *Conservation Biology* 23(6):1497–1506.
- Society for Ecological Restoration International Science and Policy Working Group (SER). 2004. *The SER International Primer on Ecological Restoration*. Society of Ecological Restoration, Science and Policy Working Group, Version 2, October, 2004. Available online at <http://www.ser.org/home>, keywords "SER International Primer."
- Turner, M.G., R.H. Gardner, and R.V. O'Neill. 2001. *Landscape ecology in theory and practice*. Springer-Verlag, New York.
- Kovach, J., Vander Zouwen, B., and Van Deelen, T. 2006. Deer population management and impacts on forest management and ecology. Wisconsin Council on Forestry, Issue Brief, Madison. Available online at <https://councilonforestry.wi.gov/>, keywords "deer population management and impacts."
- Wisconsin Department of Natural Resources (WDNR). 1995. *Wisconsin's biodiversity as a management issue: a report to Department of Natural Resources managers*. Wisconsin Department of Natural Resources, PUBL-RS-915 1995, Madison.



Appendix E. Opportunities for Sustaining Natural Communities in Each Ecological Landscape

Background

A table is provided at the end of this appendix as a quick way to determine the best places in the state for sustaining different natural communities within each ecological landscape. Natural community types are described in Chapter 7, “Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin.” In the individual ecological landscape chapters, natural communities, waterbodies, and other significant habitats for native plants and animals have been grouped together as “Ecological Features” to facilitate better integrated, larger-scale planning and management of community complexes to retain spatial connectivity and functional relationships between communities of the same and associated types. This table ranks the importance of each ecological landscape in maintaining or restoring the various natural community types (WDNR 2009). This table was used to help develop the “Ecological Features” in the individual ecological landscape chapters.

“Sustaining natural communities” means ensuring that a given natural community type will be present and will have relatively high probability potential to maintain characteristic composition, structure, context and ecological function within its natural range of variability over long periods of time (e.g., 100 years or more). Estimating the likely degree of sustainability required that each natural community type be looked at from a landscape perspective across the state or multi-state region to determine whether or not Wisconsin’s occurrences of those communities are large enough, frequent enough, intact enough, and connected enough to support the desired composition, structure, and ecological function over time. The goal of sustaining natural communities is to manage for natural community types that historically occurred in a given landscape, and either persists there at the present time or could be functionally restored.

The goal of sustainability does not preclude a “working landscape,” where both traditional (e.g., forest and agricultural products) and nontraditional (e.g., ginseng, sphagnum moss, etc.) products may be extracted from an area. People are dependent on natural resources, so to maintain economic sustainability over the long term, natural resources must be sustained. Such a philosophy allows for human use so long as the capacity of natural resources for self-renewal is not compromised. However, removing natural resources in an unsustainable way will not benefit natural communities, our economy, or the human population in the long term.

This table can help guide land and water management activities so that they are compatible with the local ecology of the ecological landscape and also maintain important components of ecological diversity and function. It should help to identify the most appropriate community types that could

be considered for management activities within each ecological landscape. Therefore, this table is intended for broad land and water management applications. For example, the table should be useful for planning and management activities related to

- working forests that provide timber and numerous other goods and services;
- wildlife and fisheries areas as well as state, county, and local parks designated to further recreational pursuits;
- identification of conservation priorities, including the selection of natural areas established to protect both rare and representative natural communities and other sensitive natural features; and
- assisting other conservation organizations by providing appropriate ecological background and context for their projects.

The information presented here can help focus management of natural communities on those geographic areas where the potential for success (and the need for conservation approaches) is greatest. It will not, however, answer specific questions regarding appropriate project scale (how big), degree of connectivity, need for restoration, or how to create a compatible landscape pattern through these management efforts. Those more detailed steps require further analysis (see Chapter 1, “Principles and Ecosystem and Landscape-scale Management,” and individual ecological landscape chapters).

Some community types may need restoration because they have been greatly reduced in size or frequency of occurrence across part or all of their state range. Other communities have been greatly modified, resulting in a simplified or otherwise altered composition or structure, limiting the ecological functions that are necessary for sustainability. Restoration could include reestablishing species composition or vegetation structure. It could also include restoring a missing, diminished, or altered ecological process or influence, such as fire or water flow. Managers also need to consider landscape effects such as fragmentation and isolation of habitat patches, reduction in patch size, changes in the pattern and context of community types, and connectivity. Representation of all successional and developmental stages associated with a given community type is an important consideration to ensure that those elements of diversity most in need of attention are maintained somewhere across a regional landscape. For example, in many forest community types, older successional stages are now rare or absent in much of Wisconsin and are especially important

to consider when planning restoration projects. In a few cases, such as northern wet-mesic forest (e.g., northern white-cedar swamp), young stands are virtually nonexistent outside of a few locations with special circumstances. Restoration opportunities and needs are discussed in greater detail in the individual ecological landscape chapters.

Data Sources for this Table

Primary data sources for the table include the Wisconsin Natural Heritage Inventory (NHI) statewide database on natural communities as of November 2009 (check the Wisconsin DNR Bureau of Natural Heritage Conservation website for current community status (WDNR 2009) and selected state and regional summaries prepared by Wisconsin DNR and other agencies and organizations. Other data sources used include Forest Inventory and Analysis (FIA) data; the Southern Forest, Savanna, and Grassland Ecosystem research project; The Nature Conservancy's Ecoregional Planning Initiative; presettlement vegetation data; the Chequamegon-Nicolet National Forest Landscape Analysis and Design (LAD) process; and the Northwest Pine Barrens study.

The purpose of the NHI data is to document and track the occurrences of rare plant and animal species and significant examples of both rare and representative natural communities. Not all community types have received equivalent inventory attention. For widespread and common types, the focus has been on large, relatively undisturbed occurrences or the older (and/or rarest) successional stages of many forest communities. For rare types such as Mesic Prairie or Algific Talus Slope, the goal is to identify and inventory as many potentially viable or restorable examples as possible. Communities that have seldom been conservation priorities, such as Alder Thicket or Shrub-carr, have received less attention than other types. For types that have only recently been discovered or recognized and described in Wisconsin (e.g., Alvar, Ephemeral Pond, Interdunal Wetland, Poor Fen), data on distribution and abundance may be incomplete, making it difficult to assess their status at this time. The importance of field inventory in addressing questions on the abundance and distribution of all of our natural communities cannot be overstated.

Description of Table

The table is organized by natural community type, and displays ecological opportunities for sustaining natural communities by ecological landscape. The following four attributes are included in the table.

1. Inventory Confidence

The confidence placed in the knowledge of natural community types occurring within each ecological landscape is indicated by two categories. The first identifies those ecological landscapes that have not been well inventoried; for these areas additional data are needed. There is incomplete knowledge about which natural community types exist, the number of occurrences, and their extent. The second category is used

to indicate that there are sufficient data about, or knowledge of, the presence of natural community types within an ecological landscape.

2. Ecological Opportunities

Opportunities for sustaining natural communities are listed as major, important, present, or absent. A **major opportunity** is defined as a community type that is represented by many significant occurrences within an ecological landscape or an ecological landscape that is appropriate for major restoration activities (see individual ecological landscape chapters for community restoration potential and need). An **important opportunity** means that a community type is not extensive or common in an ecological landscape but has a minimum of one to several significant intact occurrences that should be considered for protection and/or management. Or it means that the natural community type is restricted to just one or a few ecological landscapes within the state and should be considered for management there because of limited geographic distribution and a lack of opportunities elsewhere. If a community type is listed as **present** it means that better management opportunities exist in other ecological landscapes **or** that management opportunities have not been adequately evaluated. A blank (**absent**) indicates that the community does not occur or has not been documented there.

The intent of this table is to provide a statewide perspective on the best ecological landscapes in the state in which to manage Wisconsin's natural communities. When a community type occurs in an ecological landscape but is not listed as a major or important opportunity for management in the table, there may still be valid reasons for protecting and managing a given stand. For example, the quality may be exceptional, rare species of high conservation priority may be present, the site may provide important stopover resources for migratory species, or management and protection may maintain or enhance connectivity between other features of higher priority for that ecological landscape.

3. Natural Communities

The natural communities presented in this table are mostly derived from the work of Curtis (1959), with additions and revisions by Epstein et al. (2001). The major headings (e.g., northern forest, southern forest, oak savanna, etc.) follow the natural communities presented in the Biodiversity Report (WDNR 1995). To simplify the table and make it more useable, some natural community types from the NHI list have been combined and are presented under the broader and more inclusive and familiar Curtis type name. Other types have yet to be documented across all of their potential state range, have been insufficiently studied, or may be so rare that management opportunities in Wisconsin are unclear at this time. Also, field inventory for some community types may have preceded more recent natural community classification revisions. The table reflects the following changes from the working list presented by Epstein et al. (2001):

- Northern Mesic Forest includes Mesic Cedar Forest and Mesic Floodplain Terrace.
- Northern Wet Forest includes Black Spruce Swamp and Tamarack Swamp.
- Forested Seep, Talus Forest, and Felsenmeer are recently described types that occur in small patches across highly localized parts of the Wisconsin landscape. They are not included in the table but are mentioned and discussed in the chapters on the ecological landscapes in which they occur.
- Tamarack Fen was renamed Southern Tamarack Swamp (formerly tamarack relict, to split most tamarack forests that occur south of the Tension Zone from those of the north).
- Sand Prairie includes Sand Barrens
- Open Bog includes Muskeg and Poor Fen
- Patterned Peatland was eliminated from the table because it is extremely rare in Wisconsin and represents a complex of several distinct community types
- Emergent Marsh includes Floating-leaved Marsh
- Wild Rice Marsh has been split from Emergent Marsh.
- Inland Beach includes Lacustrine Mud Flats and Riverine Mud Flats.

Community types such as Northern Mesic Forest or Southern Dry-mesic Forest that contain potentially important variants, associations, subtypes, and successional stages (e.g., aspen to old-growth eastern white pine-red pine) are discussed in the ecological landscape chapters and in Chapter 7, “Natural Communities, Aquatic Features, and Selected Habitats in Wisconsin,” in Part 1 of this publication.

4. State Ranks

State ranks were taken from the NHI database and are an indication of how rare or imperiled each community type may be in Wisconsin. State ranks are defined in the footnote at the end of this table. State ranks are updated periodically, so users should check Bureau of Natural Heritage Conservation website information for current community status (WDNR 2009).

Natural communities are not accorded legal status that is the same as or equivalent to the “Endangered” or “Threatened” designations used for rare plants and animals.

Literature Cited

- Curtis, J.T. 1959. *The vegetation of Wisconsin: an ordination of plant communities*. University of Wisconsin Press, Madison.
- Epstein, E.J., E.J. Judziewicz, and E.A. Spencer. 2001. *Descriptions of the natural communities of Wisconsin*. Wisconsin Department of Natural Resources, Bureau of Endangered Resources, Madison.
- Wisconsin Department of Natural Resources (DNR). 1995. *Wisconsin's biodiversity as a management issue: a report to Department of Natural Resources managers*. Wisconsin Department of Natural Resources, PUBL-RS-915 1995, Madison.
- Wisconsin Department of Natural Resources (DNR). 2009. Wisconsin Natural Heritage Working List. November 2009. Wisconsin Department of Natural Resources, Bureau of Natural Heritage Conservation, Madison. Current Working List available online at <http://dnr.wi.gov/>, keyword “NHI.” Accessed March 11, 2010. *Note: The Wisconsin Natural Heritage Working List is dynamic and updated periodically as new information is available. The November 2009 Working List was used for this publication. Those with questions regarding species or natural communities on the Working List should contact Julie Bleser, Natural Heritage Inventory Data Manager, Bureau of Endangered Resources, Wisconsin DNR at (608) 266-7308 or julie.bleser@wisconsin.gov.*

OPPORTUNITIES FOR SUSTAINING WISCONSIN'S NATURAL COMMUNITIES BY ECOLOGICAL LANDSCAPE.^a

<p>See Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin," for definitions of natural community types.</p> <p>See footnotes for definitions of Opportunities, State Ranks, and Inventory Confidence.</p> <p>xx = Major Opportunity x = Important Opportunity p = Present Blank = Absent</p>	State Rank	Superior Coastal Plain*	Northwest Lowlands**	Northwest Sands*	North Central Forest*	Northern Highland*	Northeast Sands**	Northern Lake Michigan Coastal*	Central Lake Michigan Coastal*	Forest Transition*	Western Prairie**	Western Coulee and Ridges*	Southwest Savanna**	Central Sand Plains**	Central Sand Hills*	Southeast Glacial Plains**	Southern Lake Michigan Coastal**
	NORTHERN FOREST																
	Boreal Forest	S2	xx	x		x	p	p	x								
	Northern Dry Forest	S3	x	p	xx	p	x	xx	x					x	p		
	Northern Dry-mesic Forest	S3	x	x	xx	x	xx	xx	x	x	p	x		x	p	p	
	Northern Mesic Forest (includes mesic cedar and floodplain terrace)	S4	x	x	p	xx	x	x	xx	x	p	p		x	p		
	Northern Wet-mesic Forest	S3S4	x	x	x	xx	x	xx	xx	x	xx	p			p	x	p
	Northern Wet Forest	S4	x	xx	xx	xx	xx	x	x	x	xx	p	x		xx	xx	x
	Northern Hardwood Swamp	S3	x	p	x	xx	x	x	x	x		p		x	x	x	
	SOUTHERN FOREST																
	Southern Dry Forest	S3									p	xx	x	x	xx	xx	p
	Central Sands Pine – Oak Forest	S3												xx	xx		
	Southern Dry-mesic Forest	S3							x	p	x	xx	x	xx	x	xx	x
	Southern Mesic Forest	S3						p	x	p	x	xx	x	x	p	x	x
	Southern Hardwood Swamp	S2							p			p				x	x
	Floodplain Forest	S3	x		p	x	p	p	x	x	x	xx	p	xx	x	xx	p
	White Pine – Red Maple Swamp	S2										x		xx			
	Southern Tamarack Swamp	S2										x		x	x	xx	x
	Hemlock Relict	S2										xx	x	p			
	Pine Relict	S2										xx	x	p			
	SAVANNAS																
	Oak Opening	S1									x	xx	xx		p	xx	x
	Oak Woodland	S1									x	xx	xx	p	p	xx	p
	Cedar Glade	S4							x	p	x	xx	p	p	p	x	
	Pine Barrens	S2			xx		p	xx				x		xx	x		
	Oak Barrens	S2			xx							xx		xx	x		
	Great Lakes Barrens	S1	xx					p									
	SHRUB																
	Alder Thicket	S4	x	x	x	xx	x	x	p	p	x	p	x		xx	x	p
	Bog Relict	S3								p		p			x	xx	x
	Shrub Carr	S4	x	p	p	x	x	p	xx	x	x	p	xx	p	xx	xx	x
	HERBACEOUS (GRASSLAND)																
	Dry Prairie	S3									x	xx	xx	x	x	xx	
	Sand Prairie (includes Sand Barrens)	S2									x	xx	p	xx	x	p	
	Dry-Mesic Prairie	S2									x	xx	xx	x	p	xx	p
	Mesic Prairie	S1									xx	x	xx	p	p	xx	x
	Wet-Mesic Prairie	S2										x	x	p	xx	xx	xx
	Wet Prairie	SU									p	x	p	p	x	x	x

Continued on next page

OPPORTUNITIES FOR SUSTAINING WISCONSIN'S NATURAL COMMUNITIES BY ECOLOGICAL LANDSCAPE.^a

<p>See Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin," for definitions of natural community types.</p> <p>See footnotes for definitions of Opportunities, State Ranks, and Inventory Confidence.</p> <p>xx = Major Opportunity x = Important Opportunity p = Present Blank = Absent</p>	State Rank	Superior Coastal Plain*	Northwest Lowlands**	Northwest Sands*	North Central Forest*	Northern Highland*	Northeast Sands**	Northern Lake Michigan Coastal*	Central Lake Michigan Coastal*	Forest Transition*	Western Prairie**	Western Coulee and Ridges*	Southwest Savanna**	Central Sand Plains**	Central Sand Hills*	Southeast Glacial Plains**	Southern Lake Michigan Coastal**
Bracken Grassland	S2					x	xx										
Northern Sedge Meadow	S3	x	xx	xx	xx	xx	x	xx	x	x	p	x		xx	x	x	
Southern Sedge Meadow	S3							x	x	p	p	x	p	x	xx	xx	x
Surrogate Grasslands ^b	NR	x	p	xx	p		p	x	x	x	xx	xx	xx	xx	x	xx	x
HERBACEOUS OPEN WETLAND (BOG, FEN, MARSH)																	
Open Bog (includes Muskeg, Poor Fen)	S4	xx	xx	xx	xx	xx	x	p	p	x				xx	x		
Boreal Rich Fen	S2				x	x	x	xx									
Calcareous Fen (Southern)	S3											p		p	xx	xx	x
Shore Fen	S2	xx						x									
Emergent Marsh	S4	xx	x	xx	xx	xx	x	xx	x	x	xx	xx	p	x	xx	xx	x
Emergent Marsh – Wild Rice	S3	xx		xx	x	xx	p	p	p	p	p	x		p	p	x	
Submergent Marsh	S4	xx	x	xx	xx	xx	x	x	x	x	x	xx	p	x	xx	x	p
Submergent Marsh – Oligotrophic Marsh	S3			p		xx											
Coastal Plain Marsh	S1													x	xx		
Interdunal Wetland	S1	xx						x	x								
Ephemeral Pond	SU	p	p	p	xx	x	p	x	x	x	p	x	p		p	x	x
MISCELLANEOUS COMMUNITIES^c																	
Algific Talus Slope	S1											xx					
Clay Seepage Bluff	S2	x						x	x								x
Alvar	S1							x	xx								
Bedrock Glade	S3		p		xx	p	x	p	x	x	x	xx		p	x		
Dry Cliff (Curtis' Exposed Cliff)	S4	xx	p		xx		x	xx	xx	x	x	xx	x	xx	p	xx	p
Moist Cliff (Curtis' Shaded Cliff)	S4	xx	p		xx		x	x	x	x	x	xx	x	x	x	x	p
Great Lakes Alkaline Rockshore	S2							xx									
Great Lakes Bedrock Shore	S2	x															
Great Lakes Dune	S2	xx						xx	xx								x
Great Lakes Beach	S2	xx						xx	xx								p
Inland Beach	S3			xx	p	x	p								x		
Great Lakes Ridge and Swale	S2	p						xx	xx								
AQUATIC																	
Coldwater Stream	NR	xx	p	xx	xx	x	xx	p	p	xx	xx	xx	x	x	xx	p	
Coolwater Stream	NR	xx	x	xx	xx	xx	xx	x	x	xx	xx	xx	x	x	x	x	p
Impoundment ^b	NR	p	p	x	xx	x	x	x	p	xx	x	p	p	xx	xx	xx	x
Inland Lake	NR	p	p	xx	xx	xx	x	x	p	x	p			p	xx	xx	x
Lake Michigan	NR							xx	xx								xx
Lake Superior	NR	xx															
Warmwater River	NR	x	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	p	x	xx	xx	x
Warmwater Stream	NR	xx	x	x	xx	xx	p	xx	xx	xx	xx	p	xx	x	x	xx	xx

Continued on next page

Opportunities for Sustaining Wisconsin's Natural Communities by Ecological Landscape,^a continued

^aThis table does not suggest that a given ecological landscape should or could be restored to historic conditions. This may not be desirable or even possible because of environmental changes, uncertainties, and human needs. This table also does not imply that status quo management should be continued everywhere. We need to continue to improve and refine stewardship efforts to meet the needs of people and diverse, sustainable ecosystems.

^b**Surrogate Communities** – Habitats created by human activities rather than by natural processes and used by some native species through part or all of their life cycles.

^c**Miscellaneous Communities** – Soil profile poorly developed or absent (usually bare sand or bedrock) in these communities, except for Forested Ridge and Swale.

Definitions:

Major Opportunity – Natural community type extensively represented by multiple significant occurrences, or ecological landscape is appropriate for major restoration activities.

Important Opportunity – Natural community type not extensive or common in the ecological landscape but represented by one to several significant occurrences, or type restricted to one or few ecological landscapes.

Present – Better opportunities exist on other ecological landscapes, or opportunities not adequately evaluated.

Absent – Type absent, or no occurrences documented.

State Rank:

S1 = Critically imperiled in Wisconsin because of extreme rarity (five or fewer occurrences or very few remaining individuals or acres) or some factor(s) making it very vulnerable to extirpation.

S2 = Imperiled in Wisconsin because of rarity (6 to 20 occurrences or few remaining individuals or acres) or some factor(s) making it vulnerable to extirpation from the state.

S3 = Rare or uncommon in Wisconsin (21 to 100 occurrences).

S4 = Apparently secure in Wisconsin, with many occurrences.

S5 = Demonstrably secure in Wisconsin and essentially ineradicable under present conditions.

SU = Possibly in peril in the state, but the status is uncertain. More information is needed.

NR = Not ranked.

Inventory Confidence:

* Indicates that the ecological landscape has not been completely inventoried or that additional data are needed and that there is incomplete knowledge of what natural community types exist in the ecological landscape.

** Indicates that there are sufficient data or knowledge about the presence of natural community types within an ecological landscape.



Appendix F. Some Important Natural Resource Plans and Assessments

Described below are some large-scale plans that might be integrated with the recommendations of this publication. In addition, some programs that might be used to implement these recommendations are included. The date of the most recent plan update is included in parentheses, and the URL is provided if the plan is available on the web for additional information.

International, National, and Regional Plans

North American Landbird Conservation Plan (2004)

The Partners in Flight (PIF) North American Landbird Conservation Plan provides a continental synthesis of priorities and objectives that guide landbird conservation actions at national and international scales. The scope for this plan is the 448 species of native landbirds that regularly breed in the U.S. and Canada. Fully 100 of these species warrant inclusion on the Partners in Flight Watch List due to a combination of threats to their habitats, declining populations, small population sizes, or limited distributions. Of these, 28 species require immediate action to protect small remaining populations, and 44 more are in need of management to reverse long-term declines. For more information, see <https://www.partnersinflight.org>, keywords “2004 landbird conservation plan.”

Lake Superior Biodiversity Conservation Assessment Strategy (2015)

Lake Superior is unique among the world’s 253 large freshwater lakes. Situated at the top of the chain of the Great Lakes, it is the world’s largest freshwater lake, with more water than all the other Great Lakes combined. It is also a lake of extraordinary biodiversity. It contains endemic fishes, a unique deepwater form of lake trout, and the cool coastlines and islands harbor arctic-alpine plants. It is also a region of growing threats. The assessment and strategy is the first in the Great Lakes to utilize watershed, coastal zone, and water indices in the evaluation of major habitat types. For more information, see <http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/wholesystems/greatlakes/basin/biodiversity/Pages/Lake-Superior.aspx>.

Lake Michigan Biodiversity Conservation Strategy (2015)

The Lake Michigan Biodiversity Conservation Strategy (LMBCS) was initiated to provide a more in-depth assessment of the lake’s biodiversity status and threats as well as develop a comprehensive set of strategies to maintain and increase the viability of Lake Michigan’s biodiversity and abate the threats to biodiversity. The strategy was developed by The

Nature Conservancy and Michigan Natural Features Inventory and is the product of a two-year planning process involving roughly 170 individuals from 79 agencies and organizations from around the lake. The project builds on and supports similar biodiversity conservation strategies that have been completed for Lakes Ontario and Huron. For more information, see <http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/wholesystems/greatlakes/Pages/lakemichigan.aspx>.

Lakewide Management Plans (LaMP) (2013 Update)

A Lakewide Management Plan, or “LaMP,” is a plan of action to assess, restore, protect, and monitor the ecosystem health of a Great Lake. It is a multi-national means to coordinate the work of the state and federal government, tribal, and nongovernment partners working to improve the Great Lakes ecosystem. A public consultation process is used to ensure that the LaMP is addressing the public’s concerns. For more information, see <https://www.epa.gov>, keywords “Lakewide Management Plan.”

Partners in Flight regional plan – Bird Conservation Region 12 (formerly Region 20) (2009)

The Boreal Hardwood Transition Bird Conservation Region 12 extends across portions of northern Minnesota, Wisconsin, and Michigan, including the Upper Peninsula. Extensive deciduous, coniferous, and mixed forests cover the planning unit, comprising more than half its land cover. Grassland and wetland habitats also are well represented, with grassland and agricultural lands especially concentrated in the Lake Superior coastal plain and southern and western fringes of the planning unit. Major conservation issues and opportunities for the planning unit center on how to best manage northern forests. The primary challenge is how to maintain healthy, viable populations of native birds and other organisms while accommodating the growing demands placed on forest resources for timber products. Factors limiting bird populations in the Boreal Hardwood Transition involve landscape-level changes due to logging, housing development, and road building combined with the effects of natural disturbances such as fire and white-tailed deer herbivory. Other issues include threats to migratory stopover habitats and the growing concern of climate change. For more information, see <https://www.partnersinflight.org>, keywords “Region 12.”

Partners in Flight regional plan – Bird Conservation Region 23 (formerly Region 16) (2001)

The Upper Great Lakes Plain Bird Conservation Region 23 covers the southern half of Michigan, northwest Ohio, northern Indiana, northern Illinois, southern Wisconsin, and small por-

tions of southeastern Minnesota and northeastern Iowa. Glacial moraines and dissected plateaus are characteristic of the topography. Broadleaf forests, oak savannas, and a variety of prairie communities are the natural vegetation types. A "Driftless Area" was not glaciated during the late Pleistocene and emerged as a unique area of great biological diversity. There are many large urban centers in this area whose growth and sprawl will continue to consume land. The vast majority of the presettlement forest and oak savanna grasslands already have been converted to agriculture. Rates of cowbird parasitism and nest predation in this heavily fragmented region are extremely high, and it is possible that only those bird communities in the few remaining expanses of contiguous habitat are self-sustaining. Forest habitat needs to be retained or restored so that a significant number of patches of sufficient size and quality each support a healthy population of birds like the Cerulean Warbler. It is assumed that each of these patches will then support the full range of forest birds. The total area of savanna habitat also should be increased, although the need for large blocks is not as apparent. Those few areas of grassland that still exist should be retained. For more information, see <https://www.partnersinflight.org>, "Resources" pull-down menu to "bird conservation plans," then to keyword search "Upper Great Lakes."

North American Waterfowl Management Plan (2012)

The North American Waterfowl Management Plan was signed in 1986 by the Canadian Minister of the Environment and the U.S. Secretary of the Interior, which is the foundation partnership upon which hundreds of others were built. The U.S. and Canadian governments developed a strategy to restore waterfowl populations through habitat protection, restoration, and enhancement. In 1994, Mexico became a signatory to the plan.

In 1998, the plan's vision was expanded: partners implemented the plan guided by biologically based planning, which were refined through ongoing evaluation; partners defined the landscape conditions needed to sustain waterfowl and benefit other wetland-associated species; and plan partners collaborated with other bird initiatives and forged broader alliances with other sectors and communities.

The plan is international in scope, but implementation functions at the regional level. Its success is dependent upon the strength of partnerships, called "joint ventures," involving federal, state, provincial, tribal, and local governments, businesses, conservation organizations, and individual citizens. Joint ventures develop implementation plans focusing on areas of concern identified in the plan. For more information, see www.nawmprevision.org/sites/default/files/NAWMP-Plan-EN-may23.pdf.

Upper Mississippi River and Great Lakes Region Joint Venture (2007)

The mission of the Upper Mississippi River and Great Lakes Region Joint Venture (UMGLJV) is to deliver the full spectrum

of bird conservation through regionally based, biologically driven, landscape-oriented partnerships. The geographic boundary of the UMGLJV includes all of Indiana, Michigan, and Wisconsin, plus portions of Iowa, Illinois, Kansas, Missouri, Minnesota, Nebraska, and Ohio.

The UMGL JV strives for sustainable populations of all birds through regionally coordinated conservation actions based on the best scientific information and techniques available. Explicit bird population goals, decision tools, and an implementation plan are used to guide resources for efficient conservation delivery, research, and evaluation.

Five plans were developed in 2007 for the Upper Mississippi River and Great Lakes Region for landbirds, waterbirds, shorebirds, waterfowl, and an implementation plan. Since the completion of the 2007 Implementation Plan, partners within the UMGLJV have protected, restored, and enhanced more than 263,000 acres of habitat. Moreover, scientific endeavors required to answer plan assumptions have been pursued and will guide future planning documents and tools. The five plans are available at <http://www.uppermissgreatlakesjv.org/Plans.htm>.

U.S. Shorebird Conservation Plan (2001)

Partners from state and federal agencies and nongovernmental organizations from across the country pooled their resources and expertise to develop a conservation strategy for migratory shorebirds and the habitats upon which they depend. The plan provides a scientific framework to determine species, sites, and habitats that most urgently need conservation action. Main goals of the plan, completed in 2001, are to ensure that adequate quantity and quality of shorebird habitat is maintained at the local level and to maintain or restore shorebird populations at the continental and hemispheric levels. Separate technical reports were developed for a conservation assessment, research needs, a comprehensive monitoring strategy, and education and outreach. These national assessments were used to step down goals and objectives into 11 regional conservation plans. Although some outreach, education, research, monitoring, and habitat conservation programs are being implemented, accomplishment of conservation objectives for all shorebird species will require a coordinated effort among traditional and new partners. For more information, see <http://www.shorebirdplan.org/plan-and-council/>.

North American Waterbird Conservation Plan (2002)

The North American Waterbird Conservation Plan provides an overarching continental framework and guide for conserving waterbirds. It sets forth goals and priorities for waterbirds in all habitats from the Canadian Arctic to Panama, from Bermuda through the U.S. Pacific Islands, at nesting sites, during annual migrations, and during nonbreeding periods. It advocates continent-wide monitoring; provides an impetus for regional conservation planning; proposes national, state, provincial and other local conservation planning and action;

and gives a larger context for local habitat protection. Taken together, these activities will assure healthy populations and habitats for the waterbirds of the Americas. This first version of this plan emphasizes seabirds and other colonial-nesting waterbirds. It also concentrates on the northern portions of its geographic scope. Version 1 is available at <https://www.fws.gov>, keywords “waterbird conservation,” to “Waterbird Conservation for the Americas” web page. There is no printed version of an update. The new and updated plan elements are presented on-line. These elements include more guidance on conservation of non-colonial waterbirds and more details on the needs and priorities of various planning regions within the overall plan area, especially the Caribbean, Mexico, and Central America. The plan area has also been expanded to address waterbird conservation in South America.

The Nature Conservancy’s Ecoregional Plans (2002)

The Great Lakes ecoregion, which includes major portions of Canada and the United States, is one of 64 ecologically distinct regions of the continental United States. The Great Lakes ecoregional planning initiative is a systematic approach that identifies all native species, natural communities, and aquatic ecosystems characteristic of the Great Lakes region and then determines how many and where these elements of biodiversity need to be protected over the long term. In addition, this initiative identifies broad-scale threats to Great Lakes biodiversity and develops strategies to address these threats. Two plans include Wisconsin: the Superior Mixed Forest Ecoregion plan (available at https://www.conservationgateway.org/ConservationPlanning/SettingPriorities/EcoregionalReports/Documents/SMF_Ecoregional_Plan.pdf) and the Prairie-Forest Border Ecoregion plan (available at https://www.conservationgateway.org/ConservationPlanning/SettingPriorities/EcoregionalReports/Documents/PrairieForest-Border_FINALREPORT_wExhibits.pdf).

Upper Mississippi River Forest Partnership (2009)

The Upper Mississippi River Forest Partnership is a cooperative venture of the U.S. Forest Service–Northeastern Area, the Wisconsin Department of Natural Resources–Division of Forestry, and the state foresters of Illinois, Indiana, Iowa, Minnesota, Missouri, and Wisconsin. The mission is to provide solutions to environmental problems in the watershed through targeted efforts in tree and forest restoration, protection, and sustainable management. A publication entitled *Identification of Priority Forests in the Upper Mississippi River System – 2001 Land Cover Update* is available at http://na.fs.fed.us/watershed/upper_mississippi_partnership/gis/gis_update%202001data.pdf.

Northwest Sands Landscape-Level Management Plan (2000)

This report presents results of a landscape-level management planning effort for the Northwest Sands area encompassing Bayfield, Burnett, Douglas, Polk, and Washburn counties. The plan is multi-jurisdictional, encompassing multiple

land ownerships, political jurisdictions, and social service organization service areas, some of which already have plans in place for their individual ownership or organizations. The purpose of the plan was to (1) provide a comprehensive database of information that could be used by individual jurisdictions in their own planning efforts to see how they fit within the larger context and (2) to identify opportunities that individual jurisdictions could do within their individual areas of responsibility. Available from the Wisconsin DNR, 101 S. Webster Street, Madison, WI 53703.

Landscape Analysis and Design on the Chequamegon-Nicolet National Forest (1999)

This plan was instituted to take a landscape-scale look at the entire National Forest and surrounding areas in Wisconsin to meet the needs for sustaining ecosystems as well as producing forest products. It used an inventory and assessment phase to collect information and then used that information to design how the National Forest might be managed to meet biodiversity and forest product needs. This effort became part of the National Forest Planning process.

Statewide Plans and Assessments

Fisheries, Wildlife, and Habitat Management Plan (2013)

This document addresses the Wisconsin DNR Mission, implements the four goals of the Wisconsin DNR’s Strategic Plan, and provides specific information and objectives relevant to fish, wildlife, and habitat management for the eight year period from July 1, 2007 through June 30, 2015. It is required to receive federal aid via the Pittman-Robertson Restoration Act and the Sport Fisheries Restoration Act.

Wisconsin’s Biodiversity as a Management Issue (1995)

This report presents a Wisconsin DNR strategy for the conservation of biological diversity. It provides an overview of the issues associated with biodiversity and provides a common point of reference for incorporating the conservation of biodiversity into the Wisconsin DNR management framework. Available at <http://dnr.wi.gov/files/PDF/pubs/rs/rs0915.pdf>.

Wisconsin Land Legacy Report (2006)

This Wisconsin DNR plan identifies 229 places within the state believed to be most important to meet the state’s conservation and recreation needs over the next 50 years. Available at <http://dnr.wi.gov/topic/lands/landlegacy/>.

Wisconsin Statewide Comprehensive Outdoor Recreation Plan (SCORP) (2011–2016)

Since 1965 the Wisconsin DNR has developed and maintained the Statewide Comprehensive Outdoor Recreation Plan (scorp) in an attempt to classify, measure, and provide for the preferences and needs of a statewide recreating public. SCORP

examines recreational trends to assess current and future recreational needs within the state. With its comprehensive statewide and regional focus, the plan guides the allocation of limited recreation funds to acquire additional recreation and conservation lands and support the continued development of outdoor recreation opportunities. Available at <http://dnr.wi.gov/topic/parks/planning/scorp/>.

Wisconsin Wetland Team Priorities and Action Plan – Reversing the Loss (2012)

The Wisconsin Wetland Team has identified the following key priorities and actions that team organizations will work on in 2013 and 2014. This Action Plan recognizes that the condition of our economy and our water resources in the state are changing and that we must adapt to accomplish the state's overarching vision to reverse the loss of Wisconsin's wetland resources. To learn more about the long-term strategy visit <http://dnr.wi.gov/topic/wetlands/strategy.html>. For more information, in the 2013–2014 Action Plan, see <http://dnr.wi.gov/topic/wetlands/documents/2013-2014TeamPrioritiesActionPlanDec2012.pdf>.

Wisconsin Wildlife Action Plan (2005)

This Wisconsin DNR plan evaluates the native animal species that are part of Wisconsin's natural heritage, identifies those most in need of our management attention because they are declining or are dependent on habitat or places that are declining, and suggests conservation actions to ensure that Wisconsin's native species are preserved. The Wisconsin Wildlife Action Plan provides strategies on how to implement management to preserve Species of Greatest Conservation Need. Available at <http://dnr.wi.gov/topic/wildlifehabitat/actionplan.html>. (Note: the 2015 update of the Wildlife Action Plan is now available.)

Wisconsin Wildlife Action Plan (2005–2015) Implementation: Priority Conservation Actions and Conservation Opportunity Areas (2008)

This Wisconsin DNR plan narrowed the list of actions in the Wisconsin Wildlife Action Plan to the most important ones to implement immediately and identified opportunity areas where they could be implemented. Available at http://dnr.wi.gov/topic/WildlifeHabitat/documents/WAP_Implementation.pdf.

Wisconsin Statewide Forest Assessment (2010)

This Wisconsin DNR assessment helps to explain forest trends, identify other important issues, and presents an updated view of the status of forests in Wisconsin. It presents data and analyses from both public and private forests in the state. Forest benefits and services (clean water, forest products, wildlife habitat, etc.) are included in the assessment. Risks to forests (fire, insects and disease, development, etc.) are also assessed. It provides policymakers and the general public with a database of succinct, comprehensive, and scientifically sound data as well as professional experience. The assessment does not

set desired conditions but provides the knowledge needed to set strategies for maintaining sustainable forests. For more information, see <http://dnr.wi.gov/topic/ForestPlanning/assessment.html>.

Wisconsin Statewide Forest Strategy (2010)

The Statewide Forest Strategy explores how to address the trends and issues identified in the Wisconsin Statewide Forest Assessment that have the potential to significantly impact Wisconsin's forests over the next decade. It provides a long-term, comprehensive, coordinated approach for addressing the management and landscape priorities identified earlier in the Statewide Forest Assessment. For more information, see <http://dnr.wi.gov/topic/ForestPlanning/documents/WiForestStrategy-2010.pdf>.

Wisconsin Bird Conservation Initiative (WBCI) All-bird Plan (2013)

The goal of this plan is for Wisconsin partners to deliver the full spectrum of bird conservation, including both game and nongame birds, by working together in voluntary, cooperative initiatives. Bird-based projects are coordinated to ensure effective management for all birds in Wisconsin. Birds and their habitats are monitored and managed using the best available science and using ecological landscapes as the management units. For more information, see <http://www.wisconsinbirds.org/plan/index.htm>.

Karner Blue Butterfly Habitat Conservation Plan (HCP) (1999)

The Karner blue butterfly is a federally listed endangered species. Although the species is rare nationwide, it is relatively common in central and northwestern Wisconsin, especially where pine barrens, oak savannas, and mowed corridors support wild lupine, the only food of the Karner blue caterpillar. The HCP is based on a legal agreement between the U.S. Fish and Wildlife Service, the Wisconsin DNR, and an array of public and private land managers. The agreement allows Wisconsin land managers to continue operating in and around Karner blue habitat, provided they modify their activities to minimize incidental take (death, harm, or harassment) of Karner blue butterflies. For more information, see <http://dnr.wi.gov/topic/ForestPlanning/karner/karnerHCP.html>.

Lake Michigan Integrated Fisheries Plan (2014)

Among the five visions within this plan is that of “a diverse, balanced, healthy ecosystem” for Lake Michigan. This plan proposes a number of strategies, working in concert with various partners and through inter-jurisdictional cooperation. Plan elements include habitat protection and restoration for native species (e.g., walleye, smallmouth bass, yellow perch, muskellunge, Great Lakes spotted musky, northern pike, lake trout, lake sturgeon and lake herring); management of species that prey upon fish (including the native cormorant and white pelican) as well as several nonnative fish (including sea

lamprey) and wildlife species; and support of today's sport (for nonnative trout and salmon) and commercial fisheries. For more information, see <http://dnr.wi.gov/topic/Fishing/Documents/LakeMichigan/LMIFMP2015-2024Draft.pdf>.

Lake Superior Fisheries Management Plan (1988) and the Lake Superior Fishing Agreement 2005–2015 (2007)

This plan has served as the basis for managing commercial and tribal treaty harvest (in Wisconsin waters of Lake Superior) of lake trout, lake whitefish, and cisco and for controlling predation by the invasive sea lamprey. It has been largely supplanted by the Lake Superior Fishing Agreement, which focuses heavily on limiting take of lean lake trout to a sustainable level through closer monitoring. Fisheries staff who manage Lake Superior recognize the need to update the management plan by incorporating a more holistic ecosystem approach but have not yet had sufficient staff to integrate this task into their work plans. For more information, see http://dnr.wi.gov/topic/fishing/documents/lakesuperior/Lake_Superior_Fisheries_Management_Plan_1988-1998.pdf, <http://dnr.wi.gov/topic/fishing/documents/lakesuperior/LakeSuperiorFishingAgreement0515.pdf>, and a related Minnesota plan: <http://www.natureconservancy.ca/assets/documents/on/lake-superior/A-Biodiversity-Conservation-Strategy-for-Lake-Superior.pdf>

Wisconsin Water Monitoring Strategy (2014)

The Wisconsin DNR Water Division Monitoring Strategy conducts all monitoring done under the bureaus of Fisheries and Habitat Management, Watershed Management, and Drinking Water and Groundwater programs and identifies efficiencies that can be gained by working together. It also clarifies which monitoring efforts are used to meet the Clean Water Act, Fisheries, and Public Trust Doctrine objectives and prioritizes where future efforts will be focused given varying funding levels. For more information, see <http://dnr.wi.gov/topic/SurfaceWater/monitoring.html>.

Wisconsin State of the Basin Reports (2001)

These Wisconsin DNR reports provide the status of the water-based ecological resources and identify key areas for management for each of the 22 major watersheds in the state. These plans are required by EPA for federal funding. These reports can be accessed at <http://dnr.wi.gov/water/basin/>, and then by clicking on the basin of interest on the map, and then by clicking on “basin report.”

Wisconsin Great Lakes Strategy (2009)

The Wisconsin DNR Office of Great Lakes drafted a Wisconsin Great Lakes Strategy to parallel the Great Lakes Regional Collaboration in 2006. The Wisconsin Great Lakes Strategy serves as the vehicle for coordinating and allocating resources to address

Great Lakes issues. This document is used to help guide restoration and protection efforts in the Wisconsin portion of the Great Lakes Basin. For more information, see <http://dnr.wi.gov/topic/GreatLakes/documents/GLStrategy2009Final.pdf>.

Wisconsin Working Lands Initiative (2006)

This report was developed under the auspices of the Wisconsin Department of Agriculture, Trade, and Consumer Protection. Wisconsin's extensive farmland that established our character as the dairy state is rapidly disappearing to development in many parts of the state. The forested lands that built our paper and recreation industries are being sold as small, private lots. These changes are essentially irreversible and are accelerating. The goal of this plan is to find new approaches to planning and zoning and policies that promote residential and commercial development while also preventing the further loss and fragmentation of Wisconsin working lands. For more information, see <http://datcp.wi.gov/uploads/Environment/pdf/FinalRptWLISteeringCommittee.pdf>.

Property or Species Plans

Wisconsin DNR Property Master Plans

Each Wisconsin DNR property (e.g., state forest, state park, wildlife area, etc.) has a “master plan” that establishes goals and objectives for the property (or grouping of properties in the case of wildlife areas and other smaller but related properties) and identifies how it will be managed and developed. These plans are designed to involve and clearly communicate to the public how the property will look and what benefits it will provide. For more information, see <http://dnr.wi.gov/topic/lands/masterplanning/>.

County Forest Plans

County forests are operated under the direction of a fifteen-year plan. Fifteen-year plans are developed with the input of county, the State of Wisconsin, local townships, the public, and various interest groups. These forests provide revenue to the county while practicing sustainable forestry. This revenue also supports recreational uses and environmental protection. These plans are vital because it involves the public in how the county forests are managed. For more information, see <http://dnr.wi.gov/topic/CountyForests/> and <http://www.wisconsincountyforests.com/administrators/administrators-contact/>.

Fish and Wildlife Species Strategic Plans

Strategic management plans were developed by Wisconsin DNR for individual wildlife species or groups of wildlife species by Species Advisory Committees composed of wildlife species experts. These plans were used primarily in the 1980s and 1990s, but some Species Advisory Committees still update plans.

Lake Superior Basin Brook Trout Plan (2005)

This plan describes the life history, threats, and management of brook trout in Wisconsin's portion of the Lake Superior basin and its tributaries. It suggests a goal of protecting and improving self-sustaining brook trout populations and their habitat in Wisconsin's Lake Superior Basin and attempting to establish several populations that exhibit life history diversity (both stream resident and migratory "coaster" life history types). The plan lists objectives and tactics to protect and rehabilitate depleted populations. It was jointly written by the Wisconsin Department of Natural Resources and the U.S. Fish and Wildlife Service. For more information, see <http://dnr.wi.gov/topic/fishing/documents/lakesuperior/LakeSuperiorBrookTroutPlan2005.pdf>.

Endangered/Threatened Species Recovery Plans

These plans are developed by Wisconsin DNR Natural Heritage Conservation staff to ensure the recovery and survival of state endangered and threatened species.

Programs That Might Be Helpful to Achieve Land and Water Management Goals

Forest Legacy Program

The Forest Legacy Program is a partnership between Wisconsin DNR and the U.S. Forest Service to identify and help conserve ecologically important forests from conversion to non-forest uses. The main tool used for protecting these important forests is conservation easements. The federal government may fund up to 75% of program costs, with at least 25% coming from private, state, or local sources. For more information, see dnr.wi.gov/topic/ForestPlanning/legacy.html.

Forest Certification

Publishers, building contractors, and other wood manufacturing companies are expanding use of certified wood to assure customers that their products are not tainted by timber theft or destructive timber cutting issues. Independent, third-party certification means management of Wisconsin's forests meets strict standards for ecological, social, and economic sustainability. Forest certification helps Wisconsin remain competitive in global markets that increasingly demand certified raw materials. Three major land management programs are certified under third-party forest certification programs: Wisconsin State Forests – 512,000 acres; Wisconsin county forests – about 2.4 million acres in 27 counties; and Managed Forest Law properties – 2 million acres under nearly 37,000 contracts with private landowners. For more information, see <http://dnr.wi.gov/topic/TimberSales/certification.html>.

Lake Stewardship

The group Wisconsin Lakes provides a wealth of information to help lakeshore property owners and lake users achieve lake improvement goals. Local shoreland education programs can be an effective way to introduce new property owners to ways

they can manage their properties to preserve lake values. Many lake groups have put together welcome packets for new residents with resources on preserving or restoring shorelines and local regulations—such as county zoning or boating ordinances—that apply to the lake. The Wisconsin Lakes website contains links to a wide range of scientific and other information essential to sound ecological management of lakes. For more information, see <http://www.wisconsinlakes.org/index.php/lake-stewardship>.

Wisconsin Healthy Lakes Implementation Plan

This plan is an outgrowth of the statewide Healthy Lakes Initiative and is based on a fully collaborative effort among a variety of groups concerned with sound lake management. The Healthy Lakes Implementation Plan describes relatively simple and inexpensive best management practices that lakeshore property owners can implement to help improve all the values people seek in lakes. The plan also includes information on funding, accountability, promotion, and program evaluation to enable adapting lake-wide management plans to the statewide Healthy Lakes Initiative well into the future. For more information, see <http://www.uwsp.edu/cnr-ap/UWEX-Lakes/Pages/healthylakes/default.aspx>.

Mississippi River Basin Healthy Watersheds Initiative

The federal Natural Resources Conservation Service (NRCS) has established the Mississippi River Basin Healthy Watersheds Initiative (MRBI) to improve the health of the Mississippi River basin. Through this Initiative, NRCS and its partners will help producers in selected watersheds in the Mississippi River basin voluntarily implement conservation practices that avoid, control, and trap nutrient runoff; improve wildlife habitat; and maintain agricultural productivity. For more information, see http://www.nrcs.usda.gov/wps/portal/nrcs/detail/wi/programs/?cid=nrcs142p2_020764. Learn more about the Initiative for 2015 here: <http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/initiatives/?cid=stelprdb1048200>.

Wisconsin's Healthy Watershed/Ecosystem Health Assessments

In 2013, Wisconsin DNR partnered with the U.S. Environmental Protection Agency to develop a model-based assessment system for all watersheds in the state. This tool ranks each watershed based on many aspects of watershed condition, including water quality, hydrology, habitat, and biological condition. The resulting modeled predictions of both overall watershed health and vulnerability are presented in a series of maps and ranking score tables that can be used to target appropriate locations for monitoring and management actions. A companion Aquatic Ecosystem Health Assessment is made up of four main categories: hydrologic condition, habitat condition/geomorphology, water quality, and biological condition, based on a variety of metrics. For more information, see <http://dnr.wi.gov/topic/Watersheds/HWA.html>.

Landowner Incentive Program

This program is funded by USFWS and administered by the Wisconsin DNR Bureau of Natural Heritage Conservation. It helps private landowners by providing financial and technical assistance to manage and restore habitat for at-risk species and rare natural communities on their land. For more information, see <http://dnr.wi.gov/topic/endangeredresources/lip.html>.

Conservation Reserve Program

The Conservation Reserve Program (CRP) is a federal program administered through the Farm Service Agency and the Natural Resources Conservation Service that provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resources concerns on their lands in an environmentally beneficial and cost-effective manner. It encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover, such as nonnative or native grasses, wildlife plantings, trees, filter strips, or riparian buffers. Farmers receive an annual rental payment for the term of the multi-year contract. Cost sharing is

provided to establish the vegetative cover practices. The Conservation Reserve Program reduces soil erosion, protects the nation's ability to produce food and fiber, reduces sedimentation in streams and lakes, improves water quality, establishes wildlife habitat, and enhances forest and wetland resources. For more information, see <http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp>.

Agricultural Conservation Easement Program

The federal Agricultural Conservation Easement Program replaced the Wetlands Reserve Program and provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits. Under the Wetlands Reserve Easements component, the Natural Resources Conservation Service helps to restore, protect, and enhance enrolled wetlands. This program offers landowners an opportunity to establish long-term conservation and wildlife practices and protection. For more information, see <http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/acep/>.



Appendix G. Statewide Maps

Go to <http://dnr.wi.gov/topic/landscapes/maps.html> to access the statewide maps. They can be both viewed and printed from this website.

- S1. Ecological Landscapes of Wisconsin
- S2. Vegetation of Wisconsin in the Mid-1800s
- S3. Relative Tree Density in the Mid-1800s
- S4. Forest Types of the Mid-1800s
- S5. WISCLAND Landcover (1992)
- S6. Public Land Ownership, Easements and Private Land Enrolled in Forest Tax Programs
- S7. Ecologically Significant Places
- S8. Exceptional and Outstanding Resource Waters and 303(d) Degraded Waters
- S9. Dams
- S10. Water Basins
- S11. Soil Regions
- S12. Surficial Deposits
- S13. Bedrock Geology
- S14. Depth to Bedrock
- S15. Depth to Water Table
- S16. Susceptibility to Groundwater Contamination
- S17. Karst and Shallow Carbonate Bedrock
- S18. End Moraine Deposits
- S19. Ceded Territory and Native American Lands
- S20. Wetlands classified by WISCLAND (1992)
- S21. Ecological Landscapes, NHFEU Provinces, Sections, and Subsections



Appendix H. Forest Types That Were Combined into Forest Type Groups Based on Forest Inventory and Analysis (FIA) Data

Forest type group	Forest type
Aspen-birch	Aspen
Aspen-birch	Balsam poplar
Aspen-birch	Paper birch
Bottomland hardwoods	Black ash / American elm / red maple
Bottomland hardwoods	Cottonwood
Bottomland hardwoods	Cottonwood / willow
Bottomland hardwoods	Red maple / lowland
Bottomland hardwoods	River birch / sycamore
Bottomland hardwoods	Silver maple / American elm
Bottomland hardwoods	Sugarberry / hackberry / elm / green ash
Bottomland hardwoods	Sycamore / pecan / American elm
Bottomland hardwoods	Willow
Exotic hardwoods	Other exotic hardwoods
Exotic softwoods	Eastern red-cedar
Exotic softwoods	Other exotic softwoods
Exotic softwoods	Scotch pine
Maple basswood	Black cherry
Maple basswood	Cherry / ash / yellow-poplar
Maple basswood	Elm / ash / locust
Maple basswood	Hard maple / basswood
Maple basswood	Red maple / upland
Maple basswood	Sugar maple / beech / yellow birch
Nonstocked	Nonstocked
Oak-hickory	Black locust
Oak-hickory	Black walnut
Oak-hickory	Bur oak
Oak-hickory	Chestnut oak / black oak / scarlet oak
Oak-hickory	Mixed upland hardwoods
Oak-hickory	Northern red oak
Oak-hickory	Post oak / blackjack oak
Oak-hickory	Red maple / oak
Oak-hickory	White oak
Oak-hickory	White oak / red oak / hickory
Oak-pine	Eastern red-cedar / hardwood
Oak-pine	Other pine / hardwood
Oak-pine	Eastern white pine / red oak / white ash
Spruce fir	Balsam fir
Spruce fir	Black spruce
Spruce fir	Northern white-cedar
Spruce fir	Tamarack
Spruce fir	White spruce
White, red, and jack pine	Eastern hemlock
White, red, and jack pine	Eastern white pine
White, red, and jack pine	Jack pine
White, red, and jack pine	Red pine
White, red, and jack pine	Eastern white pine / hemlock



Glossary

A

Abandoned dam: Any dam abandoned in compliance with ch. 31, Wis. Stats., which requires that a permit be issued by Wisconsin DNR before a dam can be removed or otherwise abandoned to protect the affected stream and public safety.

Adaptive management: A formal, structured approach to natural resource management using a specific experimental design to deal with environmental uncertainty by making decisions as part of an on-going learning process. Monitoring the results of management actions provides a flow of information that may indicate the need to change a course of action. Scientific findings and the changing needs of society may also indicate the need to adapt resource management to new information as an ongoing and continually improving process.

Afforestation: The practice of planting trees with the intent of creating forests on land that is presently not forested, ideally conducted with regard to vegetative history and ecological suitability.

Allelopathic: A biochemical characteristic of plants, microorganisms, viruses, and fungi that allows them to produce chemical compounds that suppress or otherwise influence the growth and development of other plants in natural biological and agricultural systems. Allelopathic substances often provide plants (that possess them) an advantage in occupying their habitat, and some have the potential for use as pesticides in sustainable agricultural systems.

Alluvial fan: A fan- or cone-shaped deposit of sediment built up by streams. As a stream flows downhill, it picks up sand and other particles (alluvium) and the water carries the alluvium to a flat plain where the stream leaves its channel and spreads out creating a triangle-shaped feature or fan. As a stream's gradient and current decreases, it drops coarse-grained, poorly sorted material such as gravel and sand and even smaller pieces of sediment such as silt.

Area of Concern (AOC): An area recognized by the International Joint Commission where one or more of 14 beneficial uses (see <http://www.epa.gov/great-lakes-aocs/beneficial-use-impairments> for a description of beneficial uses) are impaired or where objectives of the Great Lakes Water Quality Agreement or local environmental standards are not being achieved.

B

Bankfull width: The stream channel width of the dominant channel with a recurrence interval of one- to two-year floods and at a location generally below the level of perennial streambank vegetation. Bankfull width is a function of

streamflow occurrence and magnitude, size and type of transported sediment, and bed and bank materials of the channel. This measurement serves as one of several elements of stream classification systems.

Basal area: Used to describe the average amount of an area (usually an acre) occupied by tree stems. It is defined as the total cross-sectional area of all stems in a stand measured at breast height and expressed as per unit of land area (typically square feet per acre). To standardize measurements, tree diameter is typically measured at 4.5 feet from the ground, or approximately diameter at breast height (DBH). Basal area is a useful index for understanding forest-wildlife habitat relationships and making timber harvest decisions. For example, percent canopy cover is correlated with basal area in pine forests. Greater pine basal area equals greater tree canopy cover; thus, as both increase, less sunlight reaches the ground. This lack of sunlight impedes growth of grasses, forbs, and shrubs that provide important food and cover for some species of wildlife. Also, high basal area may lead to a decrease in tree growth and vigor from the increased competition for crown space, nutrients, and moisture.

Baseflow: The amount of water in a stream that results from ground water discharge.

Basin ("Major basin"): A hydrologically delineated major land area defined by the primary waterbody into which the basin drains. Wisconsin has three major basins (Lake Superior, Mississippi River, and Lake Michigan), each comprised of many small watersheds.

Best management practices (BMPs): An array of voluntary technical practices that protect water quality from the effects of resource extraction. They are required under the federal Clean Water Act and in Wisconsin are developed by a multi-institutional committee led by Wisconsin DNR. Numerous federal, state, county, tribal, private industrial, and non-industrial private landowners are implementing BMPs in their land management activities.

Biological Oxygen Demand (BOD): The amount of oxygen required by bacteria while stabilizing decomposable organic matter in water under aerobic conditions at 20°C over a period of five days. The BOD test is used to determine the pollutant strength of domestic and industrial wastes in terms of the oxygen required if discharged into surface water (a lake, stream, or wetland).

Bioturbation: The reworking of soil and sediment by plants or animals. Its effects include changing the texture of sediments and displacement of microorganisms and non-living particles.

Bird Conservation Area (BCA): A grassland bird habitat model developed in Wisconsin that identifies large landscapes of 10,000 acres or more for management with a core area of 2,000 acres in permanent grassland (roughly 20% of the BCA). The remaining matrix in the BCA surrounding the core would include approximately 20–30% of the land in permanent or long-term grassland (such as permanent easements, Conservation Reserve Program lands, or pasture).

Board feet: A volumetric measurement for hardwood lumber. One board foot is 12 inches long by 12 inches wide by 1 inch thick = 144 cubic inches. It is often used to estimate the amount of lumber available from a stand of trees. Board feet are often reported in thousand board feet increments (MBH).

Brownfield: Abandoned, idle, or underused commercial or industrial properties where expansion or redevelopment is hindered by documented or potential contamination. Brownfields can vary in size, location, age, and past use, varying from a 500-acre automobile assembly plant to an abandoned corner gas station.

Buffers (or Buffer strips): A variable width area maintained with natural vegetation between a potential pollutant source (such as a crop field, parking lot, or an area treated with silvicultural chemicals) and a waterbody, which provides natural filtration and other forms of protection. In a broader ecological sense, land may exist as a buffer between two areas that may have incompatible land uses, where one land use may have the potential to cause harm or reduce the viability of the resources occurring on an adjacent, different land use.

C

Calciphilic: A term applied to an organism that prefers to grow in, or can only grow in, habitats rich in calcium, such as some plants in calcareous fens.

Calcium (Ca⁺⁺): The most abundant cation found in Wisconsin lakes. Its abundance is related to the presence of calcium-bearing minerals in the lake watershed.

Cambrian sandstone: Sandstone formed in tropical seas about 542 to 488 million years ago. The Cambrian Period is characterized by desert land areas, warm seas, and rapid early diversification of marine life.

Candidate species: A plant or animal species for which the U.S. Fish and Wildlife Service or National Oceanic and Atmospheric Administration-Fisheries has sufficient information on biological vulnerability and threats to support a proposal to list a species as federally endangered or threatened.

Carlson trophic state index (TSI): A measure of the trophic state of a body of water using measures of water quality including transparency or turbidity from Secchi disk depth readings, chlorophyll-a concentrations (algal biomass), and total phosphorus levels (usually the nutrient in shortest supply for algal growth).

Carrying capacity: The maximum number of individuals of a particular species that can be supported indefinitely and sustainably within a given environment. A more recent ecological definition would include that all species within the environment would also be sustained.

Ceded Territory: A natural resource-rich area of 22,400 square miles of northern Wisconsin that was ceded to the United States by the Lake Superior Chippewa (Ojibwe) tribes in 1837 and 1842. Each year, a portion of lakes and forests here are subject to special fisheries and gathering regulations as a result of Chippewa off-reservation treaty rights that were upheld and clarified by Federal Court rulings.

Check dam: A small dam constructed in a gully to decrease the flow velocity, minimize channel scour, and promote deposition of sediment.

Chloride (Cl⁻): Chlorine in the form of the chloride ion (Cl⁻), which in lake water is commonly considered an indicator of human activity. Agricultural chemicals, human and animal wastes, and road salt are the major sources of chloride in lake water.

Chlorophyll a: A green pigment present in all plant life and necessary for photosynthesis. The amount present in lake water depends on the amount of algae and is therefore used as a common indicator of water quality.

Chronic wasting disease: A transmissible spongiform encephalopathy disease of mule and white-tailed deer, elk, and moose. It is a transmissible neurological disease that produces small lesions in the brains of infected animals and is characterized by loss of body condition and behavioral abnormalities and is always fatal.

Civilian Conservation Corps (CCC): A former federal agency (1933–1943) organized to employ the nation's unemployed youth during the Great Depression by building roads, planting trees, improving parks, and doing other public works projects.

Coarse woody debris: Dead, woody material found on the ground that is usually greater than 4 inches in diameter. In terrestrial ecosystems, this material provides habitat for many organisms and is important for nutrient cycling. In lakes and streams, this debris provides valuable habitat for aquatic organisms and can alter water movement in streams to enhance habitat diversity.

Conservation Reserve Enhancement Program (CREP): Federal and state funding, administered through the federal Natural Resources Conservation Service (NRCS) to assist farmers with conservation practices such as shoreland buffers and wetland restoration to help control soil and nutrient runoff from fields.

Conservation Reserve Program (CRP): A federal agricultural cropland set-aside program, administered through NRCS, aimed at reducing crop surpluses on highly erodible sites and establishing perennial cover.

Cover type: A way of categorizing vegetation in a forest based on the dominant tree species. In some cases, terms are used to reference groups of commonly co-occurring species, such as “northern hardwoods” (see definition below), “swamp conifers,” and bottomland hardwoods.” Cover types may also be applied to cultural features such as cornfields or pastures.

Critical habitat: Habitat that is considered essential for a plant or animal species to complete its life cycle and sustain its population. This term is also an official designation (usually used by the U.S. Fish and Wildlife Service) for areas considered essential for the survival and recovery of federally listed threatened or endangered species and carries legal restrictions regarding its use.

Critical Habitat Designation: A state water protection program that includes formal designations and mapping of public rights features according to ch. NR 1.06, sensitive areas according to ch. NR 107, and resource protection areas (uplands within the shoreland zone). All of these elements combine to provide regulatory and management advice to the State of Wisconsin, counties, local units of government, and others who have jurisdiction over or are interested in protecting and preserving these unique habitats for future generations. Selection of waters for Critical Habitat Designation is generally done as part of the Wisconsin DNR’s biennial work planning process, and may be initiated by Wisconsin DNR staff or based upon public concerns. This selection considers three basic factors: 1) quality of the water resource, 2) amount of knowledge and information the department holds regarding the waterbody, and 3) current and future risks to the resource due to impacts of riparian development and in-lake activities.

Crustal rebound: The subsequent rise of land masses that were depressed by the weight of ice sheets during the last glacial period once the ice sheets have melted.

Cuesta: Refers to an asymmetric ridge with a long and gentle backslope that conforms to the dip of a resistant stratum or strata. The outcrop of the front slope forms a steeper or even cliff-like edge.

Cumulative impacts: Effects on the environment that result from separate, individual actions that collectively become more significant over time or space than the individual actions alone.

Cuspate foreland: A triangular protrusion of sand or pebbles into a Great Lake or other waterbody, developing mainly as a result of long-shore drift that occurs in two directions. This action merges two sandspits into one that is generally wider than it is long. Vegetation often anchors the sand, but the sparse covering of organic material and plants is fragile and can be easily degraded by trampling.

Cyprinid: A family of freshwater fish including carp, true minnows, and their relatives.

D

Daphnia: A genus of small planktonic crustaceans (1–5 millimeters in length) commonly called water fleas. *Daphnia* live in various aquatic environments ranging from acidic swamps to freshwater lakes, ponds, streams, and rivers and historically have been an important part of the food chain in Lake Michigan.

Decadal droughts: Prolonged droughts of a decade or more caused by La Niña/El Niño and/or the phases of the Pacific Decadal Oscillation and the Atlantic Multidecadal Oscillation where warm and cold ocean water currents and patterns change causing changes in the amount of precipitation occurring in different parts of the North American continent.

Deglaciation: Uncovering of land that was previously covered by a glacier or ice sheet when the ice melts.

Dendritic drainage system: A drainage pattern that has a shape resembling the pattern of the branches of a tree or veins of a leaf. There are many streams that are then joined together into the tributaries of the main river. This drainage pattern is usually formed by water erosion over long periods of time.

Density-dependent mechanism: Factors where the effects on the size or growth of a population vary with the density of the population itself. An example is when birth rates in a population decline as the population size reaches the carrying capacity of the environment.

Downburst: An outburst of air on or near the ground originating from a thunderstorm that can cause “tornado-like” damage and is sometimes called “straight-line winds.”

Drowned river mouth: A situation that is well developed along the northwestern Lake Superior shore because the eastern end of Lake Superior is rising faster (from crustal rebound) than the western end, causing lake water to “back up” at the mouths of rivers entering western Lake Superior, creating wetlands estuaries.

E

Ecological Context: The ecological setting of a particular area that includes biological and physical features, land uses, ownership, or other significant attributes of the environment.

Ecologically intact: A natural landscape that has retained all or most of the biological and physical characteristics and functions that it had prior to Euro-American settlement, while being impacted only slightly by fragmentation and other anthropogenic alterations. These areas are of sufficient size to contain, support, and maintain the complex of indigenous biodiversity of viable populations of a wide range of biota genera and species.

Ecosystem health: A measure of the robustness of ecosystems. Aspects of ecosystem health include biological diversity; soil, air, and water productivity; natural disturbances and resilience; and the capacity of the ecosystem to provide a sustainable flow of goods and services for people.

Ecosystem services: Products of functioning ecosystem communities and functions that benefit human economies and life. These include things such as flood control, soil formation, nutrient cycling, water regulation and supply, climate regulation, recreation, food and raw materials production, genetic resources, atmospheric gas balance, and pollination. These values to human health and economies provided by functional ecosystems are often unrecognized in economic analyses.

Edaphic: Relates to factors in the soil as it affects living organisms. Edaphic characteristics of the soil include such factors such as water content, acidity, aeration, and the availability of nutrients.

Elements of Biodiversity: A basic building block of the Natural Heritage Inventory database. Elements include natural communities, rare plants, rare animals, and other selected features such as colonial bird rookeries and mussel beds. An element is any biological or ecological component for which data is acquired and stored for conservation purposes.

Element occurrence (EO): An area of land and/or water in which a rare species or natural community is, or was, present. An EO should have practical conservation value for the Element as evidenced by potential continued presence and/or regular recurrence at a given location. Sites with historic presence of an Element may hold restoration potential. For species, the EO often corresponds with the local population, but when appropriate may be a portion of a population (e.g., a single breeding territory) or a group of nearby populations (e.g., metapopulation). For communities, the EO may represent a stand or patch of a natural community or a cluster of stands or patches of a natural community in close proximity. EOs are delimited on the basis of biological information rather than jurisdictional (administrative) boundaries.

End moraine: Irregular ridges of glacial sediments that form at the margin or edge of the ice sheet. These landforms represent an area where the ice margin remained in one position while the ice continued bringing sediment forward and depositing it at the base. Alternatively, end moraines may form as a glacier readvances and “pushes” soft sediment in front of it.

Entrenched meander: A geological feature created by a river that has downcut into a valley creating meanders with steep slopes on both sides of the river, leaving very little floodplain. An entrenched meander is often a sign of glacial rebound or other surface uplift, either ongoing or in the past.

Environmental analysis: An analysis of proposed and alternative actions and their predictable long and short-term environmental effects required by the Wisconsin Environmental

Policy Act. Environmental analyses include physical, biological, social, and economic factors. They range from a detailed project-specific environmental impact statement to a broader strategic analysis of issues or policies.

Environmental Protection Agency 303(d) list: Water bodies not meeting surface water quality standards of the federal Clean Water Act, as documented by the Wisconsin DNR and approved by the U.S. Environmental Protection Agency.

Ericaceous shrubs (or ericads): Evergreen shrubs in the “heath” family (Ericaceae) that are associated with acid soils of low nutrient content. The organic soils in wetlands such as bog and muskeg support many ericads but so do acid sands on some droughty upland sites. Examples of ericaceous shrubs include Labrador tea, leatherleaf, huckleberry, cranberries, and blueberries.

Exceptional Resource Waters (ERW): Surface waters that provide valuable fisheries, unique hydrologic or geologic features, outstanding recreational opportunities, or unique environmental settings and that are not significantly impacted by human activities (see ch. 102.11, Wis. Stats). An exceptional resource water is defined as a lake or stream that exhibits the same high quality resource values as outstanding resource waters but that may be impacted by point source pollution.

F

Fire shadow: An area, usually downwind of nonflammable natural features such as rivers, lakes, wetlands, or other nonflammable materials, that is not prone to burn.

Fish lift/fishway: A structure designed to allow fish and other aquatic organisms the opportunity to migrate upstream over or through a barrier such as a dam.

Flashy stream: A stream or river characterized by dramatic fluctuations in flow in which sharply higher flows in wet weather can be followed by very low flows in dry weather. Certain land uses, such as those that increase the abundance of impervious surfaces such as concrete, asphalt, or bare rock, will increase flashiness and the magnitude of flooding.

Forest certification: Systems by which independent organizations develop standards and criteria for sustainable forest management. Certificate holders can reach additional global markets by offering certified wood products. However, participants must be periodically audited to ensure continued compliance with the standards.

Forest Crop Law (FCL): A state forest management program that provides tax incentives to private landowners for following a forest management plan and encourages long-term, sustainable management of private woodlands. Together with landowner objectives, the law incorporates timber harvesting, wildlife management, water quality, and recreation to maintain a healthy and productive forest. These lands are open for public hunting (not trapping) and fishing. It was available from 1928 to 1986. The last contracts expire December 31,

2035. When the FCL contracts expire, the landowner can apply to enroll in the Managed Forest Law (MFL) program, if eligible.

Forestland: As defined by the U.S. Forest service, forestland is any land with more than 17% canopy cover.

Fuelwood: Wood of comparatively higher energy value (hickory, oak, maple, birch) that is used primarily for space heating or for conversion to another form of energy, especially electricity.

Furrowing: Digging a furrow or shallow trench in which seedling trees are planted. This often destroys the native vegetation in which the trees are planted.

G

Gap-phase windthrow or gap phase disturbance: Small-scale blowdowns, usually less than 1/10th of an acre in size. These small gaps were common in forests prior to Euro-American settlement of northern Wisconsin, allowing most of the forest to reach the old-growth stage with abundant downed woody debris, broken branches and cavities, and tip-up mounds.

Glacial refugia: Places where plant or animal species have survived the Ice Ages and whose presence implies that suitable unglaciated habitat was available there during that time.

Glochidia: Microscopic larvae of freshwater mussels that attach as external parasites on fish. Once glochidia encyst on the fish, they then transform into microscopic juveniles and drop off.

Groundwater protection area (GPA): Zone within 1,200 feet of a trout stream, outstanding resource water, or exceptional resource water. Groundwater protection areas receive special consideration regarding potential impacts to groundwater flow as part of the review of high capacity well permits.

Growing stock: Trees that are merchantable due to some combination of their species, size, and quality.

H

Heads-of-outwash: A steep ice-contact slope with a more gently sloping surface dipping away from a glacier composed predominantly of glacial river sediment. It forms at the face of a melting glacier and delimits a former ice-margin of a relatively static glacier.

High-capacity well system: A pumping system having the capacity and rate of withdrawal of all wells on one property equal to or exceeding 100,000 gallons a day or 70 gallons per minute.

High-grading: Selective logging that removes the most commercially valuable trees, leaving trees of low intrinsic monetary value, or that are stunted or of poor form.

Historical vegetation (original vegetation or vegetation prior to Euro-American settlement): As used in this book, vegetation that existed before the extensive changes induced by Euro-American settlement and during a period of relative climatic stability (i.e., from approximately 2,000 years B.P. until about the year 1850). Tree species data collected during the federal General Land Office public land survey of 1832–1866 provide a reasonable picture of historic vegetation but require consideration of successional sequences in fire-susceptible ecosystems.

Hydrophytic vegetation: A plant that grows either partly or totally submerged in water or in waterlogged soil.

I

Ice-contact hills: Hills formed by accumulated, stratified sediment left behind when meltwater flows over, within, and at the base of a motionless, melting terminus of a glacier.

Ice-walled lake plains: Mesa-like hills that were once lakes on top of a melting glacier. Streams flowing on top of the glacier deposited sediment on these lake bottoms. When the surrounding ice had completely melted, the lake bottoms became the mesa-like hilltops.

Insolation: Solar radiation that reaches the earth's surface.

International Joint Commission (IJC): A bilateral commission established under the 1909 Boundary Waters Treaty, with three representatives each from the U.S. and Canada, charged with preventing and resolving disputes over use of boundary or transboundary waters and pursuing the common good of both countries as an independent and objective advisor to the two governments. In particular, the Commission rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects; it assists the two countries in the protection of the transboundary environment, including the implementation of the Great Lakes Water Quality Agreement and the improvement of transboundary air quality; and it alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes. See <http://www.ijc.org/en/>.

K

Knife: A conical hill composed primarily of sand and cobble deposited by streams flowing on top of the ice sheet but then flowed downward through holes in the glacial ice.

Kettle lake: A landform feature created by a debris covered glacial ice block melting, resulting in a depression on the land surface. When the water table is close to the surface, kettles may fill with water and contain lakes or wetlands.

Keystone species: Species whose effects on one or more critical ecological processes or on biological diversity are much greater than would be predicted from their abundance or biomass alone, such as white-tailed deer, Passenger Pigeon, or American beaver.

Kraft or sulfate process: A paper-making process developed in 1911 that converts wood into wood pulp consisting of almost pure cellulose fibers. Wood chips are treated with a mixture of sodium hydroxide and sodium sulfide, known as white liquor, which breaks the bonds that link lignin to the cellulose.

M

Managed Forest Law (MFL): A state forest management tax incentive program established in 1986 to encourage sustainable forestry on private woodlands in Wisconsin. Together with landowner objectives, the law incorporates timber harvesting, wildlife management, water quality, and recreation to maintain a healthy and productive forest. Any landowner of 10 contiguous acres of forestland can apply for MFL enrollment. Contracts can be 25 or 50 years long, and the landowner must follow a forest management plan developed by a Wisconsin DNR certified, private consulting forester or occasionally by a Wisconsin DNR forester. At least 80% of the enrolled property must be forested and used for no other purpose except for growing trees.

Maritime forest: A natural forest that occurs on islands, found on higher ground than beach or dune areas.

Marl: A white to gray accumulation on lake bottoms caused by precipitation of calcium carbonate (CaCO_3) in hard water lakes. Marl may contain many snail and clam shells, which are also composed of calcium carbonate. While marl may gradually fill in lakes, it also precipitates phosphorus, resulting in low algae populations and good water clarity. In the past, marl was used as a fertilizer to increase the lime content of agricultural fields.

Matrix: The least fragmented, most continuous vegetation type covering a landscape within which other features of the landscape are embedded. For example, a woodland could be embedded within a matrix of an agricultural landscape or a grassland could be embedded within a matrix of a forested landscape.

Milankovitch cycles: Long-term variations in the orbit of the Earth that result in changes in climate over periods of hundreds of thousands of years and are related to ice age cycles.

Mississippi Embayment: A physiographic feature in the south-central United States that is part of the Mississippi Alluvial Plain. It is a northward continuation of the fluvial sediments of the Mississippi River Delta to its confluence with the Ohio River at Cairo, Illinois.

Mosaic: The collective variety of plant communities, cover types, and other natural or anthropogenic features occurring across a landscape.

Municipal wells: Wells that serve a residential population of 25 or more people/day.

Mycorrhizal association: A mutualistic association between fungi and the roots of a plant.

N

Natural range of variability (also called the historic range of variability or natural range of variation): The range of sustainable conditions in an ecosystem as determined by time, ecological processes (such as fire), native species, and the land itself. For instance, ecosystems that have a 10-year fire cycle have a narrower range of variation than ecosystems with a 200–300-year fire cycle.

Navigable: In a legal sense, the classification of a waterbody or waterway with a bed and banks that is capable of floating a canoe or other small craft on a regular, recurring basis, if only during spring runoff. These waters are subject to protection under the Public Trust doctrine that declares all navigable waters are “common highways and forever free” and held in trust by the Wisconsin DNR.

Niagara Escarpment: A prominent and ecologically important bedrock formation of limestone and dolomite that extends for over 200 miles from southeastern Wisconsin north and east along Horicon Marsh and Lake Winnebago, the Door Peninsula, and the Grand Traverse Islands in Lake Michigan (from there it continues eastward across Upper Michigan, southern Ontario, and parts of New York State, forming Niagara Falls). In some locations in Wisconsin, the rock is exposed as cliffs, talus slopes, and shorelines, including in the Door Peninsula and the Grand Traverse Islands.

Nipissing Great Lakes: The combined waters of the upper three Great Lakes (lakes Superior, Michigan, and Huron) after the glacier had receded completely from the Great Lakes Basin around 7,500 years before present. A narrow strait connected each of the three Great Lakes resulting in the water level in all lakes being at the same elevation as a single body of water. The outlet of the lakes was eastward from Georgian Bay.

Nongame: Species that are not hunted, trapped, or fished. Many are protected species, and some that are very rare are given stronger protections under endangered species laws.

O

Oak grubs: Young oak shoots that have sprouted from the roots of an oak tree that has been cut or top-killed by fire.

Old drift: All the material picked up, mixed, disintegrated, transported, and deposited by glacial ice or water from melting glaciers is glacial drift. “Old drift” refers to such materials moved by glacial events and forces occurring prior to the start of the most recent (Wisconsinan) period of glaciation in North America (about 75,000 to 10,500 years ago). The Kansan, Nebraskan, Illinoian, and other glacial advances occurred during this period of Earth’s ice ages, which began about 2 million years ago (see “End Moraine Deposits” in Appendix G, Statewide Maps).

Old forest: Forests that are older than the typical managed forest (beyond traditional rotation age), but are not biologically old. Ages of old forests differ by the types of trees present.

See detailed discussion in *Old-Growth and Old Forests Handbook* (Handbook 2480.5, Wisconsin DNR 2006; see “General References and Recommended Readings” herein).

Old-growth forests: Forests that are relatively old and relatively undisturbed by humans. The forest is biologically old, containing some trees that are nearing or beyond their average expected lifespan. The original overstory, established following a catastrophic disturbance or series of small-scale disturbances over a long period of time, includes senescing or senescent trees. The physical structure of such forests may be extremely complex. See detailed discussion in *Old-Growth and Old Forests Handbook* (Handbook 2480.5, Wisconsin DNR 2006). Old-growth stages of many forest types were formerly common and/or widespread in Wisconsin but are now very rare.

Oligotrophic: The trophic state of a lake that is naturally nutrient poor, contains little organic material, has a poorly developed littoral zone, and plentiful oxygen content. Oligotrophic lakes are generally clear, deep and free of aquatic plants or large algae blooms. They are low in nutrients and do not support large fish populations. However, oligotrophic lakes often develop a food chain capable of sustaining a fishery of large game fish.

Ordovician sandstone: Sandstone formed in tropical oceans during the period beginning 488 million years ago and ending 444 million years ago. The Ordovician is best known for its diverse marine invertebrates, including graptolites, trilobites, brachiopods, and the conodonts (early vertebrates).

Organochlorine pesticides: A large group of pesticides and other synthetic organic compounds with chlorinated aromatic molecules such as aldrin, DDT, or dieldrin. As a variety of persistent organic pollutants, they have higher molecular stability, lower biodegradability, and pose a high risk to the environment and human health.

P

Paleoecology: A branch of ecology studying the interaction between fossil organisms and their environment.

Pediment: A broad, gently sloping surface of low local relief adjacent to an eroding cliff or mountain range. It develops when sheets of running water (laminar sheet flows) deposit sediments rather than being deposited by streams flowing in well-defined channels.

Periglacial relicts: Plants and animals that survived near the edge of a glacier during glacial times but now only occur in isolated areas where microclimates provide favorable conditions.

Persistent bioaccumulative toxin (PBT): long-lasting substances such as DDT and its derivatives, PCBs, lead, mercury, and flame retardants that can build up to harmful levels as they progress up the food web.

Pervious paving: Hard surfaces used in construction projects designed to allow percolation or infiltration of water through the surface into the soil below where the water is naturally filtered and many pollutants are removed.

Peshtigo Fire: On October 8–9, 1871, a forest fire burned an area of 1.2 million acres across portions of six northeastern Wisconsin counties, obliterating the towns of Peshtigo and Brussels and killing 1,500–2,500 people.

Physiognomic aspect: The overall structure or physical appearance of the landscape: landform, surficial geology, and vegetation.

Phytoliths: Rigid, microscopic structures in some plant tissues that are made of silica. When these plant tissues decompose, the silica is deposited in the soil forming a record of past vegetation.

Pillars: A geological landform consisting of a steep and often vertical column of rock formed by erosion of the surrounding material.

Pit-and-mound topography: An irregular surface of the forest floor created by the uprooting of trees leaving a pit where the roots were located in the soil and a mound where the decayed roots and uprooted soil form a mound. These features provide a great diversity of microhabitats and mix forest floor organic matter with mineral soils. It is a dominant feature in many old-growth forests in the Great Lakes Region.

Pitted (“collapsed”) outwash: An outwash plain characterized by numerous depressions such as kettles, shallow pits, wetlands, and potholes. These depressions formed when ice blocks covered with glacial till melted and collapsed, leaving a depression.

Polychlorinated biphenyls (PCBs): A broad family of man-made organic chemicals known as chlorinated hydrocarbons that have a range of toxicity to the environment and humans. PCBs were domestically manufactured from 1929 until their manufacture was banned in 1979.

Polycyclic aromatic hydrocarbons (PAHs): Byproducts of petroleum processing or combustion, many of which are highly carcinogenic at relatively low levels. They are relatively insoluble in water, but they are an environmental concern because they are toxic to aquatic life and because several are human carcinogens.

Population Source: An area where sufficient offspring are produced to maintain local populations and disperse into the surrounding landscape.

Private well: For regulatory purposes, any well that is not a community well (or public well) serving fewer than 25 people per day.

Proglacial: The area immediately ahead of a glacier often with outwash or ice- or moraine-dammed lakes called proglacial lakes. Glacial Lake Wisconsin was a proglacial lake.

Public rights flow: The water quantity or level necessary to protect public rights and interests in any specific body of water. A public rights flow should be of sufficient volume and depth to protect fish and wildlife (including aquatic life) and their respective habitats. Public rights include transportation on navigable waters, water quality and quantity, recreational activities, and scenic beauty.

R

Rare: As used in this book, “rare” refers to species, natural communities, or other natural features that are included on the Wisconsin DNR’s Natural Heritage Working List. This includes species that are legally designated as “Endangered” or “Threatened” as well as species in the advisory “Special Concern” category and those on the U.S. Fish and Wildlife Service’s “Candidate” and “Species of Concern” lists. As used in this book, “rare” also refers to “Species of Greatest Conservation Need,” identified in Wisconsin’s Wildlife Action Plan that may not have a formal designation under one of the above categories.

River reaches: A continuous length of surface water with similar hydrologic characteristics, such as a stretch of stream between the confluences of two tributaries.

Recessional moraines: A series of transverse ridges behind a terminal moraine. They form perpendicular to lateral moraines and are composed of unconsolidated debris deposited by the glacier, marking a temporary halt in the retreat of a glacier.

Red clay wetlands: In Wisconsin the term is most often used in reference to wetlands that occur on the poorly drained red clay soils (glacio-lacustrine deposits) of the Superior Coastal Plain Ecological Landscape bordering Lake Superior.

Refugia: Places where plant or animal species have survived despite widespread or life-threatening disturbances such as glaciation or fire.

Relict/relict communities: A community that formerly had a much wider distribution but now occurs only very locally.

Research Natural Area: A U.S. Forest Service land network that protects good examples of natural ecosystems for the purposes of scientific study and education and for maintenance of biological diversity.

Resilience: The ability of an ecosystem to maintain diversity, integrity, and ecological processes following a disturbance.

Retention time (also turnover rate or flushing rate): The average length of time water resides in a lake, ranging from several days in small impoundments to many years in large lakes (such as lakes Superior and Michigan). Retention time is important in determining the impact of nutrient inputs. Long retention times result in recycling and greater nutrient retention in most lakes.

Rough fish: Native and exotic fish not having commercial or sport fishing value, such as suckers (species not listed as threatened or endangered), common carp, goldfish, freshwater drum, burbot, bowfin, garfish, sea lamprey, alewives, gizzard shad, rainbow smelt, and mooneye.

Run of the river: A mode of hydroelectric plant operation that discharges water for electric energy production through a dam at a rate of flow approximating the natural rate of flow of the river. This practice avoids some of the ecological consequences of hydropower dams that hold water until power is needed (peaking plants) and then releases large amounts of water at times of peak electricity demand. Some of the ecological consequences avoided by “run of the river” plants are the elimination of small floods, introduction of frequent, artificial high-flow pulses that can sweep organisms away, and lowering of river levels that can strand mussels and other organisms. It also avoids extreme water level fluctuations in the storage reservoir, which can be detrimental to many species living in the lake-like environment of the impoundment.

S

Sandscapes: Several different kinds of sandscapes are common on Lake Superior. Beaches along bays or coves are the most common landscape. Sand spits are long, narrow sand deposits that extend outward from the tip of land or at the mouth of a bay. Cuspate forelands are similar to sand spits, but are more wedge-shaped, nearly as wide as they are long. Sand deposits that connect an island to the mainland or two islands to each other are called tombolos. The formation of a landscape requires three factors: a source of sand, water or wind currents to carry the sand, and a calm area where sand can accumulate.

Sand slug: A wave or pulse of sand and other material on the stream bed carried downstream by a heavy flow. This often creates a rise in elevation of the stream bed, smothers stream-bed habitat and can decrease a stream’s ability to convey flood flows without spilling over its banks. Sand slugs are most often related to abnormal stream flows resulting from land clearing and other land use changes that reduce water infiltration and increase runoff and erosion directly to the stream.

Sawtimber: A forestry term referring to living merchantable trees with some criteria of quality (which varies by grading system) of at least nine inches diameter at breast height (DBH) for softwoods such as pine or of at least 11 inches DBH for hardwoods such as sugar maple, yellow birch, or ash.

Scale: In ecosystem management, scale refers to size or extent. In terms of conservation objectives, for example, spatial scale can range from areas of less than 50 acres to areas of more than 10 million acres.

Scalping: The practice of scraping off the turf or top layer of soil in preparation for planting seedling trees. This destroys any native vegetation that was present.

Scrub oak: A vernacular term for a forest type having more than 50% of the basal area composed of any combination of black, white, northern pin, red, or bur oaks, generally found on sandy, droughty, low-nutrient, or disturbance-prone sites. Scrub oak is characterized by stands of oak exhibiting variable densities with individual trees developing a stunted, gnarly, or shrubby form. The term “scrub oak” encompasses oak barrens and oak savanna community types, or stunted oak forests, since the range of stem density and percent crown cover are not well-defined. Scrub oak is often a component of the pine barrens community, and can regenerate vegetatively either by sprouting from stumps or from root systems after fire.

Second growth: Trees that cover an area after the removal of the original forest stand by logging.

Secchi disk: An 8-inch diameter circular plate with alternating quadrants painted black and white used to measure water clarity or conversely turbidity. The disk is lowered into the water until it disappears from view to determine the secchi disk reading. Turbidity is important in aquatic systems as it can alter light intensities through the water column, thus affecting rates of photosynthesis and the distribution of organisms within the water column.

Seiche: A natural process occurring when atmospheric pressure changes and winds blow in a constant direction and piles water up on a downwind shore. When the wind drops, the water is released and flows back to the opposite shore. For example, when a seiche moves towards the head of Green Bay, it acts as a dam, slowing the discharge of rivers and creeks into the bay or even forcing water to reverse course and move upstream. Seiches can be especially dramatic in funnel-shaped bays where great volumes of water are pushed into increasingly smaller areas. This phenomenon is particularly important at sites such as Green Bay, Chequamegon Bay, and in the estuaries associated with the St. Louis and Mink rivers.

Sensitive Area Designation: A Wisconsin DNR use designation for shallow bays and other areas of navigable waters, designed to protect aquatic vegetation, loon nesting sites, and other aquatic habitat features. Use restrictions such as slow-no-wake, horsepower limits, motor prohibitions, or other management actions may be prescribed by ordinance by the local unit of government with authority over the waterbody. This designation is based upon a Sensitive Area Survey Report compiled by water management specialists, using reliable field data specific to that water.

Setbacks: The distance from a river or stream, a shore or floodplain, wetland, or any other ecological feature that is deemed in need of protection from beyond which land development may not be permissible (as part of a shoreland zoning ordinance) or logging cannot be conducted (as part of forestry BMPs).

Shoreland: Wisconsin statutes define shoreland to include lands adjacent to navigable waters within 1,000 feet of the ordinary high-water mark of a lake, pond, or flowage and within 300 feet of the ordinary high-water mark of a floodplain of a river.

Short-rotation plantations: Trees planted and harvested on a very short rotation (e.g., five years). Fast-growing species like hybrid poplar (*Populus x canadensis*) and black willow (*Salix nigra*) are typically grown for energy production and require intensive cultivation techniques, including fertilization and herbicides. Short-rotation plantations are very simplified ecosystems with potentially significant negative implications for biodiversity, depending on what existing habitats they replace.

Soil bulk density: An indicator of soil compaction. It is calculated as the dry weight of soil divided by its volume. The bulk density of soil depends greatly on the mineral make up of soil and the degree of compaction. Bulk density increases with compaction and tends to increase with depth. Soils with a bulk density higher than 1.6 g/cm³ tend to restrict root growth.

Splash dam: A temporary dam, usually of timbers, created to float winter-sawn logs to market in spring. Release of the large volume of water needed to carry quantities of logs downstream was often very destructive to the stream ecosystem, creating deeply incised channels downstream, scouring out gravel and sediment, removing large woody debris, and disconnecting the river from its floodplain.

State Natural Area (SNA): A site formally designated by the State of Wisconsin to protect outstanding examples of both representative and rare native plant communities, aquatic and geologic features, or archaeological sites. State Natural Areas are often among the last refuges in the state for rare and endangered species of plants and animals. State Natural Areas are devoted to scientific research, the teaching of conservation biology and, especially, to the preservation of natural values and genetic diversity for future generations. (For more information regarding Wisconsin's State Natural Areas, visit the Wisconsin DNR's State Natural Areas Web pages: <http://dnr.wi.gov>, keywords “State Natural Areas.”

Stochastic events: Events containing a random element, hence unpredictable and without a stable pattern or order.

Stream morphology: The channel shape and flow pattern of a stream or river. Water and sediment discharge, substrate, and gradient determine the dimensions of a stream channel (width, depth, and type of meanders).

Stream segment: A specific length of a stream and its associated substrate, fish, invertebrates, other aquatic life, vegetation, hydraulic characteristics, or physical habitat attributes.

Streambank Protection Area: An area generally 66 feet on either side of a stream that is purchased under a perpetual easement by Wisconsin DNR to provide public access for angling and to protect water quality and fish habitat along

quality streams threatened by agricultural and urban runoff. This program was established in 1990 as a supplement to the traditional Fisheries Areas Program. Habitat restoration to improve water quality and manage fish habitat are sometimes conducted along these stream corridors.

Stratification: The layering of water in deeper lakes due to differences in density caused by temperature. The density of water is greatest at 39° F (4° C). As water warms during the summer, it remains near the surface while colder water remains near the bottom. Wind mixing determines the thickness of the warm surface water layer (epilimnion), which typically extends to a depth of about 20 feet. The narrow transition zone between the surface water and cold bottom water (hypolimnion) is called the metalimnion or thermocline.

Stumpage: The value of standing timber. Usually it is calculated in board feet, cubic meters, or some other forestry measure.

Sulfate (SO₄): The most common form of sulfur in natural waters, where it results primarily from soil minerals in the watershed. Sulfate (SO₄⁻) can be reduced to hydrogen sulfide (H₂S) under low or zero oxygen conditions that harm fish. Sulfate (SO₄⁻) input from acid rain is a major indicator of sulfur dioxide (SO₂) air pollution. Sulfate concentration is used to distinguish acid lakes acidified by acid rain from those acidified by organic acids from bogs.

Supercanopy: a tree crown clearly above the main canopy, receiving light from all sides. They add structure to the forest canopy and often provide important habitat for wildlife.

Supraglacial till: sediment carried on top of an ice sheet and deposited as the ice sheet melts.

Sustainable forestry: The practice of managing dynamic forest ecosystems to provide ecological, economic, social, and cultural benefits for present and future generations (see s. 28.04 (1), Wis. Stats.).

T

Talus slopes: A steep rocky slope at the base of a cliff composed of rock fragments falling from the exposed bedrock loosened by mechanical weathering.

Temperate deciduous forest biome: The temperate deciduous forest biome occupies most of the eastern part of the United States and southern Ontario. There are eight major forest regions within the biome, each dominated by a different species or association of species.

Tension Zone: A zone that stretches across Wisconsin from northwest to southeast in a shallow S-shape. The tension zone is marked by a climatic gradient, with cooler, moister conditions to the north and relatively warmer, drier conditions to the south. This zone contains species associated with both northern and southern Wisconsin, with many occurring at the extent of their respective ranges.

Tile drainage: A subsurface drainage system installed in agricultural fields designed to lower the water table so agricultural crops can be grown. Usually a tile system uses buried pipes that move excess subsurface water out of a field.

Timberland: As defined by the U.S. Forest Service, timberland is forestland that is producing, or is capable of producing, more than 20 cubic feet per acre per year of industrial wood crops under natural conditions, that is not withdrawn from timber utilization, and that is not associated with urban or rural development. Currently inaccessible and inoperable areas are included.

Tombolo: A sand or gravel bar connecting an island with the mainland or another island. Tombolos may feature swales between the sand ridges that support a variety of wetland types including submergent aquatic, emergent aquatic, coastal fen, coastal bog, alder thicket, and tamarack swamp communities.

Tombolo: A sand or gravel bar connecting an island with the mainland or another island. Tombolos may feature swales between the sand ridges that support a diverse array of herbaceous and forested wetland communities.

Total maximum daily loads (TMDLs): A regulatory term used by the U.S. Environmental Protection Agency to define the maximum quantity of a pollutant that a body of water can receive while still meeting water quality standards. A TMDL must be developed for each impaired waterbody in the state and requires actions to restore clean water by examining water quality problems, identifying sources of pollutants, and specifying solutions.

Trophic state: A designation of the degree to which eutrophication has occurred in a lake. Trophic states are based on lake fertility and are classified based on the amount of available nutrients (phosphorus and nitrogen) for organisms. More fertile lakes have more nutrients and therefore more plants and algae. Lake trophic states are classified as: oligotrophic (nutrient poor), mesotrophic (moderately productive), and eutrophic (very productive and fertile).

Turnover: The process of a lake's water "turning over" from top to bottom. During the summer the surface layer is the warmest as it is heated by the sun. The deepest layer is the coldest because the sun's radiation does not reach this cold, dark layer. During the fall, the warm surface water begins to cool and becomes denser causing it to sink. This dense water forces the water on the bottom to rise, "turning over" the temperature-stratified layers. Wind and wave action also help to mix the entire lake.

Type conversion: The conversion of the dominant vegetation in an area from one cover type to another or from one plant community to another.

Tunnel channel: Tunnel channels form as meltwater rushes under a glacier toward the ice margin and erodes sediment and/or bedrock beneath the glacier leaving a valley when the glacier retreats.

U

Uneven-aged management: Management actions that maintain a forest or stand of trees differing in age. Harvest methods that develop and maintain uneven-aged stands are single-tree selection and group selection.

Use tax or use value: Under Wisconsin tax law, property taxes are lower on agricultural land and are assessed based on the land's ability to produce farm income. Taxes on most other real and personal property continue to be assessed at full market value, which is the estimated sales price. By reducing assessments on agricultural land, the use value law was intended both to improve Wisconsin's farm economy by providing property tax relief for farmers and to reduce urban sprawl. However, this has encouraged farmers and rural landowners to convert natural areas to agricultural crops or pastures to get a reduced property tax rate.

W

Waterfowl Production Areas (WPA): Scattered lands that are usually small in size that are part of the U.S. Fish and Wildlife Service's National Wildlife Refuge System to preserve wetlands and grasslands critical to waterfowl and other wildlife. WPAs are either acquired as public land or are private land protected through perpetual easements.

Water Quality Management Area (WQMA): Areas of land designated by Wisconsin statutes to maintain water quality standards of waterbodies that are within 1,000 feet of the ordinary high water mark of a lake, pond, or flowage, or within 300 feet of navigable rivers or streams, or that are susceptible to groundwater contamination, due to high groundwater or shallow bedrock.

Western Montane: Refers to plants and animals commonly occurring in and associated with the mountainous ecosystems of western North America. The presence of such species in our region offers clues to past geologic and climatic conditions.

West Nile virus: A mosquito-borne zoonotic arbovirus found in temperate and tropical regions of the world that can negatively affect wildlife species and humans. Birds are the most commonly infected animal and serve as the primary reservoir host.

Wetland Reserve Program: A federal program (implemented by the U.S. Department of Agriculture's Natural Resources Conservation Service), with state partnering, to voluntarily restore wetlands that were previously drained or filled for crop production and to preserve riparian areas through conservation easements on private property. The landowner voluntarily limits future use of the land via an easement and receives payment for the easement and cost-sharing for wetland restoration, yet retains private ownership.

White-nose syndrome (WNS): An emerging fungal disease caused by a fungus from Eurasia, which was accidentally transported here by humans. It is a disease of hibernating bats that has spread from northeastern to central United States at an alarming rate. Since the winter of 2007–2008, at least 5.7 million bats have died from this devastating disease, and as of 2017 the fungus is found in 31 states and five Canadian provinces.

Winegar Moraine: A major end moraine created during the retreat of Wisconsin glaciation that extends across northern Wisconsin and southern Upper Michigan. It includes ice-stagnation features, end moraines, ground moraine, and outwash. Irregular lobes of end moraine in which kettles and steep ridges make up most of the landscape are characteristic of both the Michigan and Wisconsin part of this moraine.

Wing and sluice dams: Dams built to raise the water level, increase the current, and channel logs downriver to sawmills.

Wisconsin Dome: A gradual uplifting of Precambrian rocks in north-central Wisconsin and a portion of the adjacent Upper Peninsula of Michigan during the past 200 million years, which resulted in land that is higher than the surrounding areas. This led to the exposure and erosion of much of the sedimentary rock layers in this region.

Witness tree: Prominent trees used by surveyors in the mid-1800s to locate corners of original land surveys. A mark would be cut into the trunk and location of the witness tree noted in the surveyor's field report.



Recommended Readings and References

This section contains references and recommended readings that apply to the entire publication. References that are specific to a chapter can be found at the end of a given chapter. This section is divided into two parts: Field Guides and References on Wisconsin's Biota and Landscapes and General References and Recommended Readings.

Field Guides and References on Wisconsin's Biota and Landscapes

Many excellent local references are available, and some of these have been cited in the individual ecological landscape chapters in *The Ecological Landscapes of Wisconsin*. Publications that focus on Wisconsin or the upper Midwest are highlighted here. This is not an exhaustive and all-inclusive list of guides and related references (for example, all of the Wisconsin Geological and Natural History Survey's county publications could be cited here, as could the "modern" county soil surveys). We have cited many of those publications elsewhere in the book.

Field guides that cover broad geographic areas such as all or large parts of North America (e.g., the Peterson series) have generally been left off of this list. For several taxa (e.g., mosses and sedges), recent publications provide the best available information on difficult, or poorly known but significant, groups of organisms. Publications from nearby states or provinces have been included when they are more current or comprehensive than what is available locally (when the Wisconsin publications are out-of-print or hard to obtain for other reasons) or because of their general excellence and overall utility. In some cases there was simply nothing else available.

Mammals

- Harvey, M., J. Altenbach, and T. Best. 1999. *Bats of the United States*. Arkansas Fish and Game Commission, Little Rock. 64 pp.
- Jackson, H. 1961. *Mammals of Wisconsin*. University of Wisconsin Press, Madison.
- Kurta, A. 2005. *Mammals of the Great Lakes region*. Revised edition. The University of Michigan Press, Ann Arbor. 376 pp.
- Taylor, D. 2006. *Forest management and bats*. Bat Conservation International, Austin, Texas.

Birds

- Cutright, N., B. Harriman, and R. Howe. 2006. *Atlas of the breeding birds of Wisconsin*. Wisconsin Society for Ornithology, Waukesha, Wisconsin. 602 pp.
- Mossman, M., and D. Lange. 1982. *Breeding birds of the Baraboo Hills, Wisconsin: their history, distribution and ecology*. Wisconsin Department of Natural Resources and The Wisconsin Society for Ornithology, Madison.

- Robbins, S. 1991. *Wisconsin birdlife*. University of Wisconsin Press, Madison. 702 pp.
- Sample, D., and M. Mossman. 1997. *Managing habitat for grassland birds: a guide for Wisconsin*. Wisconsin Department of Natural Resources, Bureau of Integrated Science Services, PUB-SS-925-97, Madison.
- Steele, Y., editor. 2007. *Important bird areas of Wisconsin: critical sites for the conservation and management of Wisconsin's birds*. Wisconsin Department of Natural Resources, Madison.
- Temple, S., J. Cary, and R. Rolley. 1997. *Wisconsin birds: A seasonal and geographical guide*. Second edition. University of Wisconsin Press, Madison. 320 pp. Wisconsin Breeding Bird Atlas maps available online at <http://www.uwgb.edu/birds/wbba/>.

Amphibians and Reptiles

- Christoffel, R., R. Hay, and M. Monroe. 2002. *Turtles and lizards of Wisconsin*. Wisconsin Department of Natural Resources, Bureau of Endangered Resources, PUB-ER-104 2002, Madison. 49 pp.
- Christoffel, R., R. Hay, R. Paloski, and L. Ramirez. 2008. *Snakes of Wisconsin*. Second edition. Wisconsin Department of Natural Resources, Bureau of Endangered Resources, PUB-ER-100 2008, Madison.
- Christoffel, R., R. Hay, R. Paloski, and M. Wolfgram. 2009. *Amphibians of Wisconsin*. Second edition. Wisconsin Department of Natural Resources, Bureau of Endangered Resources, PUB-ER-105 2009, Madison.
- Harding, J. 1997. *Amphibians and reptiles of the Great Lakes region*. University of Michigan Press, Ann Arbor, Michigan.
- Oldfield, B., and J. Moriarty. 1994. *Amphibians and reptiles native to Minnesota*. University of Minnesota Press, Minneapolis.
- Vogt, R. 1981. *Natural history of amphibians and reptiles of Wisconsin*. Milwaukee Public Museum and Friends of the Museum, Inc., Milwaukee. 205 pp.
- Wisconsin Department of Natural Resources. 2016. Wisconsin frog and toad survey. Website. Available online at <http://wiatri.net/inventory/frogtoadsurvey/>.
- Wisconsin Partners in Amphibian and Reptile Conservation (PARC) website, <http://wiparc.org/>.

Fish

- Becker, G. 1983. *Fishes of Wisconsin*. University of Wisconsin Press, Madison. 1082 pp.
- Lyons, J., P. Cochran, and D. Fago. 2000. *Fishes of Wisconsin 2000: status and distribution*. University of Wisconsin, Sea Grant Institute, Madison. 87 pp.
- Wisconsin Department of Natural Resources, University of Wisconsin Center for Limnology, and University of Wisconsin Sea Grant Institute. 2015. Wisconsin fish identification database. Website. Available online at <http://www.sea-grant.wisc.edu/home/Default.aspx?tabid=604>.

Mussels

- Fuller, S., Brynildson, I., Hay, R., Heath, D. and L. Kitchel. 2003. *Freshwater mussels of the Upper Mississippi River*. Wisconsin Department of Natural Resources, Madison. 61 pp.
- National Native Mussel Conservation Committee. 1998. National strategy for the conservation of native freshwater mussels. *Journal of Shellfish Research* 17(5):1419-1428.
- Williams, J., M. Warren, Jr., K. Cummings, J. Harris, and R. Neves. 1993. Conservation status of freshwater mussels of the United States and Canada. *Fisheries* 18(9):6-22.

Butterflies and Moths (Lepidoptera)

- Ebner, 1970. J. *Butterflies of Wisconsin*. Milwaukee Public Museum. Popular Science Handbook No. 12. 205 pp.
- Ferge, L., and G. Balogh. 2000. *Checklist of Wisconsin moths (Superfamilies Drepanoidea, Geometroidea, Miallonoidea, Bombycoidea, Sphingoidea and Noctuoidea)*. Milwaukee Public Museum, Contributions in Biology and Geology No. 93, Milwaukee. 55 pp.
- Opler, P. and G. Krizek. 1984. *Butterflies east of the Great Plains*. The Johns Hopkins University Press, Baltimore. 294 pp.
- Reese, M. 2015. Wisconsin butterflies. Website. Available online at <http://wisconsinbutterflies.org/>.
- Wisconsin Department of Natural Resources. 2011. Wisconsin's rare butterflies and moths. Web page. Last update June 2011. Available online at <http://dnr.wi.gov/>, keywords "rare butterflies and moths."

Dragonflies and Damselflies (Odonata)

- Dubois, B. 2005. *Damselflies of the north woods*. Kollath-Sensaas Publishing Company, Duluth, Minnesota. 128 pp.
- Legler, D., and K. Legler. 2007. *Color guide to dragonflies of Wisconsin*. Edition 4.5. Karl and Dorothy Legler, Sauk City, Wisconsin. 68 pp.
- Mead, K. 2003. *Dragonflies of the north woods*. Kollath-Stensaas Publishing, Duluth, Minnesota. 203 pp.

Miscellaneous Invertebrates

- Hale, C. 2007. *Earthworms of the Great Lakes*. Kollath and Stensaas Publishing, Duluth, Minnesota.
- Kirk, K., and C. Bomar. 2005. *Guide to the grasshoppers of Wisconsin*. Wisconsin Department of Natural Resources, Bureau of Integrated Science Services, Madison. 154 pp.
- Wisconsin Department of Natural Resources. 1999. *The endangered and threatened invertebrates of Wisconsin*. Wisconsin Department of Natural Resources, Bureau of Endangered Resources, PUB-ER-085-99, Madison. 80 pp.

Plants

- Barnes, B., and W. Wagner. 1981. *Michigan trees: A guide to the trees of Michigan and the Great Lakes Region*. University of Michigan Press, Ann Arbor. 384 pp.
- Black, M., and E. Judziewicz. 2009. *Wildflowers of Wisconsin and the Great Lakes Region*. Second edition. University of Wisconsin Press, Madison. 275 pp.

- Boos, T., K. Kearns, C. LeClair, B. Panke, B. Sriver, and B. Williams, editors. 2010. *A field guide to terrestrial invasive plants in Wisconsin*. Wisconsin Department of Natural Resources, Madison.
- Borman, S., R. Korth, and J. Temte. 1997. *Through the looking glass a field guide to aquatic plants*. Wisconsin Department of Natural Resources, PUB FH-207-97, Madison.
- Case, F. 1987. *Orchids of the Great Lakes region*. Cranbrook Institute of Science, Bulletin 48, revised edition, Bloomfield Hills. 253 pp.
- Chadde, S. 1998. *A Great Lakes wetland flora*. Pocketflora Press, Calumet, Michigan. 569 pp.
- Cochrane, T., and H. Iltis. 2000. *Atlas of the Wisconsin savanna and prairie flora*. Wisconsin Department of Natural Resources, Technical Bulletin No. 191, Madison. 226 pp.
- Cochrane, T., K. Elliot, and C. Lipke. 2006. *Prairie plants of the University of Wisconsin-Madison Arboretum*. University of Wisconsin Press, Madison, Wisconsin.
- Courtenay, B., and J. Zimmerman. 1972. *Wildflowers and weeds*. Van Nostrand Reinhold Co., New York. (Currently out of print – look for it in online used book stores.)
- Crum, H. 2004. *Mosses of the Great Lakes forest*. Fourth edition. University of Michigan Herbarium, Ann Arbor. 592 pp.
- Czarpata, E. 2005. *Invasive plants of the upper Midwest: an illustrated guide to their identification and control*. University of Wisconsin Press, Madison.
- Fassett, N. 1957. *A manual of aquatic plants*. University of Wisconsin Press, Madison. 405 pp.
- Fassett, N. (updated by O. Thomson). 1976. *Spring flora of Wisconsin*. University of Wisconsin Press, Madison.
- Hipp, A. 2008. *Field guide to Wisconsin sedges*. University of Wisconsin Press, Madison.
- Judziewicz, E. 1993. Flora of the Apostle Islands. *The Michigan Botanist* 32(2):43–189.
- Judziewicz, E. 2001. Flora and vegetation of the Grand Traverse Islands (Lake Michigan), Wisconsin and Michigan. *The Michigan Botanist* 40(4):81–208.
- Mahlberg, P., and M. Mahlberg. 2001. *Wildflowers of Door County*. Indiana University Press, Bloomington 240 pp.
- Ownbey, G., and T. Morley. 1991. *Vascular plants of Minnesota, a checklist and atlas*. University of Minnesota Press, Minneapolis.
- Peck, J., and C. Taylor. 1980. Check list and distribution of Wisconsin ferns and fern allies. *The Michigan Botanist* 19:251–268.
- Reed, D., and S. Eggers. 1987. *Wetland plants and plant communities of Minnesota and Wisconsin*. U.S. Army Corps of Engineers, St. Paul District, St. Paul, Minnesota. 201 pp.
- Rothrock, P. 2009. *Sedges of Indiana and the adjacent states: the non-Carex species*. Indiana Academy of Science, Indianapolis. 270 pp.
- Smith, W. *Orchids of Minnesota*. University of Minnesota Press, Minneapolis. 173 pp.
- Smith, W. 2008. *Trees and shrubs of Minnesota*. University of Minnesota Press, Minneapolis. 640 pp.

- Swink, F., and G. Wilhelm. 1994. *Plants of the Chicago region*. Fourth Edition. Indiana Academy of Science, Indianapolis. 921 pp.
- Thomsen, J. 2003. *Lichens of Wisconsin*. University of Wisconsin-Madison Herbarium, Madison. 386 pp.
- Voss, E. 1972. *Michigan flora: Part I, Gymnosperms and monocots*. Cranbrook Institute of Science, Bulletin 55, and University of Michigan Herbarium. Bloomfield Hills, Michigan. 488 pp.
- Voss, E. 1985. *Michigan flora: Part II, Dicots (Saururaceae-Cornaceae)*. Cranbrook Institute of Science, Bulletin 59, and University of Michigan Herbarium, Ann Arbor. 724 pp.
- Voss, E. 1996. *Michigan flora: Part III, Dicots (Pyrolaceae-Compositae)*. Cranbrook Institute of Science, Bulletin 61, and University of Michigan Herbarium, Ann Arbor. 622 pp.
- Weatherbee, E. 2006. *Great Lakes plants*. University of Michigan Press, Ann Arbor. 180 pp.

Frequently Referenced Plant Websites

- University of Wisconsin-Madison. 2016. Flora of Wisconsin. Website. Available online at <http://wisflora.herbarium.wisc.edu>.
- U.S. Department of Agriculture Natural Resources Conservation Service. 2016. Plants database. Website. Available online at <http://plants.usda.gov/>.
- Fewless, G. Trees of Wisconsin. Website. Available online at http://uwgb.edu/biodiversity/herbarium/trees/tree_intro01.htm or <http://www.uwgb.edu/biodiversity/herbarium/index.asp>, plant lists and keys link.
- Fewless, G. Shrubs of Wisconsin. Website. Available online at http://uwgb.edu/biodiversity/herbarium/shrubs/shrub_intro01.htm or <http://www.uwgb.edu/biodiversity/herbarium/index.asp>, plant lists and keys link.
- Fewless, G. Ferns and fern allies of Wisconsin. Website. Available online at http://www.uwgb.edu/biodiversity/herbarium/pteridophytes/pteridophytes_of_wisconsin01.htm or <http://www.uwgb.edu/biodiversity/herbarium/index.asp>, plant lists and keys link.

Vegetation, Plant Community Classification, and Plant Habitats

A more complete bibliography on this topic can be found in Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin."

- Anderson, R., J. Fralish, and J. Baskin. 1999. *Savannas, barrens, and rock outcrop plant communities of North America*. Cambridge Press, New York, New York.
- Cowardin, L., V. Carter, F. Golet, and E. LaRoe. 1979. *Classification of wetlands and deepwater habitats of the United States*. U.S. Fish and Wildlife Service, Washington, D.C. 103 pp.
- Crum, H. 1988. *A focus on peatlands and peat mosses*. University of Michigan Press, Ann Arbor, Michigan. 306 pp.
- Curtis, J. *Vegetation of Wisconsin: an ordination of plant communities*. University of Wisconsin Press, Madison.

- Eggers, S.D., and D.M. Reed. 2014. *Wetland plants and plant communities of Minnesota and Wisconsin*. Version 3.1 – May 2014. U.S. Army Corps of Engineers, St. Paul District, St. Paul. 68 pp.
- Faber-Langendoen, D., editor. 2001. *Plant communities of the Midwest: classification in an ecological context*. Association for Biodiversity Information, Arlington, Virginia. (Note: The Association for Biodiversity Information is now "NatureServe".)
- Kost, M.D., Albert, J. Cohen, R. Schillo, C. Weber, and K. Chapman. 2007. *Natural communities of Michigan: classification and description*. Michigan Natural Features Inventory, Lansing, Michigan. 343 pp.
- Kotar, J., and T. Burger. 1996. *A guide to forest communities and habitat types of central and southern Wisconsin*. University of Wisconsin-Madison, Department of Forestry, Madison.
- Kotar, J., J. Kovach, and T. Burger. 2002. *A guide to forest habitat types of northern Wisconsin*. Second edition. University of Wisconsin-Madison, Department of Forestry, Madison.
- Lammert, M., J. Higgins, D. Grossman, and M. Bryer. 1997. *A classification framework for freshwater communities*. The Nature Conservancy, Great Lakes Program Office, Chicago, Illinois (Lammert and Higgins) and The Nature Conservancy, Ecology Department, Conservation Science Division, International Headquarters (Grossman and Bryer), Arlington, Virginia.
- Lyons, J. 2005. *Aquatic communities: description, threats, and conservation recommendations*. Wisconsin Department of Natural Resources, Bureau of Integrated Science Services, Madison.
- Minnesota Department of Natural Resources. 2003. *Field guide to the native plant communities of Minnesota: the Laurentian Mixed Forest Province*. Minnesota Department of Natural Resources, Ecological Land Classification Program, Division of Forestry; Minnesota County Biological Survey, Division of Ecological Resources; Natural Heritage and Nongame Research Program, Division of Ecological Resources, St. Paul. 352 pp.
- Minnesota Department of Natural Resources. 2005. *Field guide to the native plant communities of Minnesota: The Eastern Broadleaf Forest Province*. Minnesota Department of Natural Resources, Ecological Land Classification Program, Division of Forestry; Minnesota County Biological Survey, Division of Ecological Resources; Natural Heritage and Nongame Research Program, Division of Ecological Resources, St. Paul. 394 pp.
- Minnesota Department of Natural Resources. 2005. *Field guide to the native plant communities of Minnesota: the Prairie Parkland and Tallgrass Aspen Parklands Provinces*. Minnesota Department of Natural Resources, Ecological Land Classification Program, Division of Forestry; Minnesota County Biological Survey, Division of Ecological Resources; Natural Heritage and Nongame Research Program, Division of Ecological Resources, St. Paul. 362 pp.
- O'Connor, R. M. Kost, and J. Cohen. 2009. *Prairies and savannas in Michigan: Rediscovering our natural heritage*. Michigan State Press, East Lansing, Michigan. 139 pp.
- Omernik, J., S. Chapman, R. Lillie, and R. Dumke. 2008 (last update). *Ecoregions of Wisconsin*. Wisconsin Department of

Natural Resources, Madison. Available online at http://dnr.wi.gov/topic/SurfaceWater/datasets/omernik_eco/. (Note: *Ecoregions of Wisconsin* was originally published in 2000 in *Transactions of the Wisconsin Academy of Sciences, Arts, and Letters* 88:77–103.)

Swindale, D., and J. Curtis. 1957. Phytosociology of the larger submerged plants in Wisconsin Lakes. *Ecology* 38:397–407.

Physical Environment

Clayton, L., and J. Attig. 1989. *Glacial Lake Wisconsin*. Geological Society of America Memoir 173, Geological Society of America, Boulder, Colorado. 80 pp.

Dott, R., and J. Attig. 2004. *Roadside geology of Wisconsin*. Mountain Press Publishing Company, Missoula, Montana. 346 pp.

Dunne, T., and L. Leopold. 1978. *Water in Environmental Planning*. W. H. Freeman and Company, San Francisco. 818 pp.

Hadley, D., and J. Pelham. 1976. *Glacial deposits of Wisconsin: sand and gravel resource potential*. Wisconsin Geological and Natural History Survey, State Map Series, Map No. 10, Madison. Map at 1:500,000 scale.

Hole, F. 1976. *Soils of Wisconsin*. University of Wisconsin Press, Madison. 223 pp.

LaBerge, G. 1994. *Geology of the Lake Superior region*. Geoscience Press, Inc., Tucson, Arizona. 313 pp.

Lange, K. *Ancient rocks and vanished glaciers: a natural history of Devil's Lake State Park, Wisconsin*. Worzalla Publishing Company, Stevens Point, Wisconsin. 154 pp.

Lillie, R., and J. Mason. 1983. *Limnological characteristics of Wisconsin lakes*. Wisconsin Department of Natural Resources, Bureau of Research, Technical Bulletin 138, PUBL-RS-138 1983, Madison.

Martin, L. 1965. *The physical geography of Wisconsin*. University of Wisconsin Press, Madison, WI. 608 pp.

Mudrey, M., M. Brown, and J. Greenberg. 1982. *Bedrock geology of Wisconsin*. Wisconsin Geological and Natural History Survey, State Map Series, Map No. 18, Madison. Map at 1:1,000,000 scale.

Ostrum, M. 1981. *Bedrock geology of Wisconsin*. Map. Wisconsin Geological and Natural History Survey, Madison. Map at 1:500,000 scale.

Paull, R.A., and R.K. Paull. 1977. *Geology of Wisconsin and Upper Michigan: including parts of adjacent states*. Kendall/Hunt Publishing Company, Dubuque, Iowa. 232 pp.

Schultz, G. 1986. *Wisconsin's foundations*. Kendall/Hunt Publishing Company, Dubuque, Iowa. 211 pp.

Webb, T., P. Bartlein, S. Harrison, and K. Anderson. 1993. Vegetation, lake levels, and climate in eastern North America for the past 18,000 years. In H. Wright, Jr., J. Kutzbach, T. Webb, W. Ruddiman, F. Street-Perrott, and P. Bartlein, editors. *Global climates since the last glacial maximum*. University of Minnesota Press, Minneapolis.

Welsch, J. 1992. *Guide to Wisconsin aquatic plants*. Wisconsin Department of Natural Resources, Water Resources program, PUBL-WR-173, revised 1992, Madison.

Wisconsin Geological and Natural History Survey. Website. Available online at <http://wgnhs.uwex.edu>. Note: *The WGNHS website is an excellent source of maps and publications on Wisconsin's bedrock and Pleistocene geology, landforms, ground and surface waters.*

Miscellaneous References: Anthropology, Natural History, Land Use

Birmingham, R., C. Mason, and J. Stoltman, editors. 1997. Wisconsin Archeology. *The Wisconsin Archeologist* 78(1–2): Special Issue published in cooperation with the Wisconsin Archaeological Survey, Inc., the State Historical Society of Wisconsin, and the Wisconsin Department of Transportation. 358 pp.

Cortner, H., M. Shannon, M. Wallace, S. Burke, and M. Moote. 1996. *Institutional barriers and incentives for ecosystem management: a problem analysis*. U.S. Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-354, Portland, Oregon. 35 pp.

Diamond, J. 2005. *Collapse: How societies choose to fail or succeed*. Viking Press, New York.

Henderson, R., and S. Statz. 1995. *Bibliography of fire effects and related literature applicable to the ecosystems and species of Wisconsin*. Wisconsin Department of Natural Resources, Technical Bulletin 187, Madison.

Higgins, K. 1986. *Interpretation and compendium of historical fire accounts in the northern Great Plains*. U.S. Fish and Wildlife Service, Resource Publication 161, Washington, D.C.

Lapham, I. 2001. *The antiquities of Wisconsin: as surveyed and described*. (Facsimile of 1855 publication). University of Wisconsin Press, Madison.

Mann, C. 2005. *1491: New revelations of the Americas before Columbus*. Vintage Books, New York, New York. 541 pp.

Stoltman, J., and D. Baerreis. 1983. The evolution of human ecosystems in the eastern United States. Pages 252–298 in H. Wright, Jr., editor. *The Holocene*. Volume 2. University of Minnesota Press, Minneapolis.

Tanner, H., editor. 1987. *Atlas of Great Lakes Indian history*. University of Oklahoma Press, Norman, Oklahoma. 224 pp.

Trigger, B., editor. 1978. *Handbook of North American Indians. Volume 15: The Northeast*. Smithsonian Institution, Washington, D.C. 924 pp.

Waller, D., and T. Rooney, editors. 2008. *The vanishing present: Wisconsin's changing lands, waters, and wildlife*. University of Chicago Press, Chicago. 507 pp.

Wisconsin Cartographers' Guild. 1998. *Wisconsin's past and present: A historical atlas*. The Board of Regents of the University of Wisconsin System. Wisconsin University Press, Madison. 123 pp.

Wisconsin Department of Natural Resources. 2016. Protecting Wisconsin's biodiversity. Web page. Last update January 13, 2016. Available online at <http://dnr.wi.gov/>, keywords "Wisconsin's biodiversity."

Wisconsin Board of Commissioners of Public Lands. 2015. Wisconsin's Public Land Survey. Available online at <http://digicoll.library.wisc.edu/SurveyNotes/>, "search" tab.

General References and Recommended Readings

- Altenbach, J.S. 1995. Entering mines to survey bats effectively and safely. In B.R. Riddle, editor. *Inactive mines as bat habitat: guidelines of research, survey, monitoring and mine management in Nevada*. Biological Resources Research Center, University of Nevada, Reno.
- Altenbach, J.S., and E.D. Pierson. 1995. The importance of mines to bats: an overview. In B.R. Riddle, editor. *Inactive mines as bat habitat: guidelines of research, survey, monitoring and mine management in Nevada*. Biological Resources Research Center, University of Nevada, Reno.
- Anderson, C., L. Ayers, T. Bergeson, K. Grveles, K. Kirk, W.A. Smith, and S. Zolkowski. 2008. *Biodiversity in selected natural communities related to global climate change*. Wisconsin Department of Natural Resources, Bureau of Endangered Resources, final report to Wisconsin Focus on Energy, Environmental Research Program, Madison.
- Annin, P. 2006. *The Great Lakes water wars*. Island Press, Washington, D.C. 303 pp.
- Audubon and Cornell Lab of Ornithology. 2012. Understanding radar and birds. Web page. Available online at <http://ebird.org/content/ebird/news/radar/>. Last update March 16, 2012.
- Augustine, D., and L. Frelich. 1998. Effects of white-tailed deer on an understory forb in fragmented deciduous forests. *Conservation Biology* 12(5):995–1004.
- Becker, G. 1983. *Fishes of Wisconsin*. The University of Wisconsin Press, Madison. 1052 pp.
- Bernthal, T.W., and K.G. Willis. 2004. *Using LANDSAT 7 imagery to map invasive reed canary grass (Phalaris arundinacea): a landscape level wetland monitoring methodology*. Wisconsin Department of Natural Resources, Final Report to the U.S. Environmental Protection Agency, Region V, PUB-SS-992 2004, Madison. 73 pp.
- Bordner, J.S. 1927–1947. *Wisconsin Land Economic Inventory*. Available online at <http://digital.library.wisc.edu/1711.dl/EcoNatRes.WILandInv>, “search the collection” tab.
- Bowser, C.J. 1992. Groundwater pathways for chloride pollution of lakes. In F.M. D'Itri, editor. *Chemical deicers and the environment*. Lewis Publishers Inc. Chelsea, Michigan.
- Boyce, M., and A. Haney, editors. 1997. *Ecosystem management: applications for sustainable forest and wildlife resources*. Yale University Press, New Haven. 361 pp.
- Chamberlain, J., R. Bush, and A.L. Hammett. 1998. Non-timber forest products: the other forest products. *Forest Products Journal* 48(10):2–12.
- Cleland, D.T., P.E. Avers, W.H. McNab, M.E. Jensen, R.G. Bailey, T. King, and W.E. Russell. 1997. *National Hierarchical Framework of Ecological Units*. Pages 181–200 in M.S. Boyce and A. Haney, editors. *Ecosystem management applications for sustainable forest and wildlife resources*. Yale University Press, New Haven. Available online at http://files.dnr.state.mn.us/natural_resources/ecs/nhfeu.pdf.
- Cortner, H., M. Shannon, M. Wallace, S. Burke, and M. Moote. 1996. *Institutional barriers and incentives for ecosystem management: a problem analysis*. U.S. Forest Service, Pacific Northwest Research Station, General Technical Report, PNW-GTR-354, Portland, Oregon. 35 pp.
- Crow, T.R., A. Haney, and D.M. Waller. 1994. Report on the scientific roundtable on biodiversity convened by the Chequamegon and Nicolet National Forests. U.S. Forest Service, North Central Forest Experiment Station, General Technical Report NC-166, St. Paul. 55 pp.
- Curtis, J.T. 1959. *The vegetation of Wisconsin: an ordination of plant communities*. University of Wisconsin Press, Madison. 657 pp.
- Cutright, N., B. Harriman, and R. Howe. 2006. *Atlas of the breeding birds of Wisconsin*. The Wisconsin Society for Ornithology, Waukesha, Wisconsin. 602 pp.
- Durand, L., and K. Bertrand. 1935. The forest and woodland regions of Wisconsin. *Geographical Review* 25:264–271.
- Edwards, P., R. May, and N. Webb. 1994. *Large-scale ecology and conservation biology*. Blackwell Scientific Publications, London. 375 pp.
- Faber-Langendoen, D., J. Nichols, L. Master, K. Snow, A. Tomaino, R. Bittman, G. Hammerson, B. Heide, L. Ramsay, A. Teucher, and B. Young. 2012. *Conservation status assessments: methodology for assigning ranks*. NatureServe, Arlington, Virginia.
- Forman, R.T.T. 1995. Some general principles of landscape and regional ecology. *Landscape Ecology* 10(3):133–142.
- Frieswyck, C., and J. Zedler. 2007. Vegetation change in Great Lakes coastal wetlands: variation from the historical cycle. *Journal of Great Lakes Research* 33(2):360–380.
- Frieswyck, C., C. Johnston, and J. Zedler. 2008. Quantifying and qualifying dominance in vegetation. *Journal of Great Lakes Research* 33:125–135.
- Green, J. 1995. *Birds and forests: a management and conservation guide*. Minnesota Department of Natural Resources, St. Paul. 182 pp.
- Grumbine, R. 1994. What is ecosystem management? *Conservation Biology* 8(1):27–38.
- Hagan, J., and D. Johnston, editors. 1992. *Ecology and conservation of Neotropical migrant landbirds*. Smithsonian Institution Press, Washington, D.C.
- Hatch, B.K., and T.W. Bernthal. 2008. *Mapping Wisconsin wetlands dominated by reed canary grass, Phalaris arundinacea L.: A landscape level assessment*. Wisconsin Department of Natural Resources, Final Report to the U.S. Environmental Protection Agency, Region V. Wetland Grant # 96544501-0. 28 pp.
- Howe, R.W., G. Neimi, G., and J.R. Probst. 1995. Management of western Great Lakes forests for the conservation of Neotropical migratory birds. Pages 144–167 in *Management of midwestern landscapes for the conservation of Neotropical migratory birds*. U.S. Forest Service, North Central Forest Experiment Station, General Technical Report NC187, Detroit.
- Hunter, M., editor. 1999. *Maintaining biodiversity in forest ecosystems*. Cambridge University Press, Cambridge, England. 698 pp.
- Isebrands, J., and R. Dickson. 1994. *Biology and silviculture of*

- northern red oak in the North Central Region: a synopsis*. U.S. Forest Service, North Central Forest Experiment Station, St. Paul. 68 pp.
- Judziwicz, E., and J. Nekola. 1997. Recent Wisconsin records for some interesting vascular plants in the Western Great Lakes region. *The Michigan Botanist* 36:91–118.
- Keast, A., and E. Morton, editors. 1980. *Migrant birds in the neotropics: ecology, behavior, distribution, and conservation*. Smithsonian Institution Press, Washington, D.C.
- Kohm, K., and J. Franklin. 1997. *Creating a forestry for the 21st century: the science of ecosystem management*. Island Press, Washington, D.C. 475 pp.
- Lillie, R., P. Garrison, S. Dodson, R. Bautz, and G. LaLiberte. 2002. *Refinement and expansion of wetland biological indices for Wisconsin: final report to the U.S. Environmental Protection Agency, Region V*. Wisconsin Department of Natural Resources, Bureau of Integrated Science Services, Madison.
- Luyssaert, S., E.D. Schulze, A. Börner, A. Knohl, D. Hessenmöller, B.E. Law, P. Ciais, and J. Grace. 2008. Old-growth forests as global carbon sinks. *Nature* 455:213–215 (11 September 2008), doi:10.1038/nature07276.
- MacClintock, L., R. Whitcomb, and B. Whitcomb. 1977. Evidence for the value of corridors and minimization of isolation in the preservation of biotic diversity. *American Birds* 31(1):6–16.
- Max Planck Institute. 2006. Global warming—the blame is not with the plants. *ScienceDaily* January 26, 2006. Available online at www.sciencedaily.com/releases/2006/01/060125082122.htm.
- Miller, J., M. Groom, G. Hess, T. Steelman, D. Stokes, J. Thompson, T. Bowman, L. Fricke, B. King, and R. Marquardt. 2008. Biodiversity conservation in local planning. *Conservation Biology* 23(1):53–63.
- Missall, S. 1999. Developing on state shorelines will get tougher. *Daily Journal of Commerce*, Special Issue: Protecting the Environment Available online at <http://www.djc.com/special/enviro99/10057218.htm>.
- Oregon State University. 2008. Old growth forests are valuable carbon sinks. *Science Daily* September 14, 2008. Available online at www.sciencedaily.com/releases/2008/09/080910133934.htm.
- Rankin, S., and S. Crispin. 1994. *The conservation of biological diversity in the Great Lakes ecosystem: issues and opportunities*. The Nature Conservancy, Great Lakes Program, Chicago. 118 pp.
- Rappole, J. 1995. *The ecology of migrant landbirds: a Neotropical perspective*. Smithsonian Institution Press, Washington, D.C.
- Rawinski, T. 2008. *Impacts of white-tailed deer overabundance in forest ecosystems: an overview*. U.S. Forest Service, Newtown Square, Pennsylvania. 8 pp.
- Robbins, S., Jr. 1991. *Wisconsin birdlife: population and distribution, past and present*. University of Wisconsin Press, Madison. 702 pp.
- Scheffer, M. 2001. *Ecology of shallow lakes*. Kluwer Academic Publishers, Boston, MA.
- Stanturf, J. A., and P. Madsen, editors. 2005. *Restoration of boreal and temperate forests*. CRC Press, New York. 569 pp.
- Terborgh, J. 1989. *Where have all the birds gone?* Princeton University Press, Princeton, New Jersey.
- The Nature Conservancy. 1994. *The conservation of biological diversity in the Great Lakes ecosystem: issues and opportunities*. The Nature Conservancy, Great Lakes Program, Lansing, Michigan.
- University of Wisconsin Extension. 2014. Wisconsin's healthy lakes implementation plan, 2014–2017. University of Wisconsin Extension, Wisconsin Department of Natural Resources, and Wisconsin Lakes Partnership. Available online at <http://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/resources/healthylakes/HealthyLakesPlan.pdf>.
- University of Wisconsin Extension. 2016. Wisconsin's healthy lakes. Web page. Available online at <http://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/healthylakes/default.aspx>.
- U.S. Census Bureau (USCB). 2013. North American Industry Classification System. Web page. Available online at <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2007>.
- Verry, E., J. Hornbeck, and C. Dolloff. *Riparian management in forests of the continental eastern United States*. Lewis Publishers, New York. 402 pp.
- Waller, D., and T. Rooney. 2008. *The Vanishing present: Wisconsin's changing lands, waters, and wildlife*. University of Chicago Press, Chicago. 507 pp.
- Watermolen, D., and M. Murrell. 2001. *Checklists of Wisconsin vertebrates*. Wisconsin Department of Natural Resources, Bureau of Integrated Science Services, PUB-SS-954 2001, Madison.
- Wilson, D., editor. 2008. *Managing from a landscape perspective: a guide for integrating forest interior bird habitat considerations and forest management planning in the Driftless Area of the Upper Mississippi River Basin*. Version 1.1. Driftless Area Initiative. Wisconsin Department of Natural Resources, PUB-FR-421-2008, Dodgeville, Wisconsin.
- Wisconsin Conservation Congress. 2000. *Deer management for 2000 and beyond: a Wisconsin Conservation Congress Initiative*. Series of reports to the Wisconsin Department of Natural Resources, Madison. Contact Wisconsin DNR, Wildlife Management, Madison, for a copy.
- Wisconsin Department of Natural Resources. 2010. *Managing forests on Wisconsin State Park lands*. Wisconsin Department of Natural Resources, Bureau of Parks and Recreation, Madison. Available online at <http://dnr.wi.gov/topic/parks/documents/forestmanagement.pdf>.
- Wisconsin Department of Natural Resources. 2000. *Wisconsin forests at the Millenium: an assessment*. Wisconsin Department of Natural Resources, Division of Forestry, Madison. 125 pp.
- Wisconsin Department of Natural Resources. 2006. *Old-growth and old forests handbook*. Wisconsin Department of Natural Resources, Handbook 2480.5, Madison.
- Wisconsin Department of Natural Resources. 2008. *Biotic inventory and analysis of the Flambeau River State Forest: a baseline inventory and analysis of natural communities, rare plants, and animals*. Wisconsin Department of Natural Resources, Bureau

- of Endangered Resources, PUB ER-808 2008, Madison.
- Wisconsin Paper Council website. 2016. The history of paper. Web page. Available online at <http://wipapercouncil.org/about-paper/history-of-paper/>.
- Wisconsin Department of Natural Resources (WDNR). 2005. *Wisconsin's strategy for wildlife species of greatest conservation need*. Wisconsin Department of Natural Resources, Wisconsin Wildlife Action Plan, PUB-ER-641 2005, Madison. Available online at <http://dnr.wi.gov/>, keywords "wildlife action plan." (Note: the 2015 update of the Wildlife Action Plan is now available. See the Wisconsin DNR Wildlife Action Plan web page.)
- Wisconsin Department of Natural Resources. 2008. *Wisconsin's Wildlife Action Plan (2005–2015) implementation: priority Conservation Actions and Conservation Opportunity Areas*. Wisconsin Department of Natural Resources, with assistance from conservation partners, Madison.
- Yaffee, S., A. Phillips, I. Frenx, P. Hardy, S. Maleki, and B. Thorpe. 1996. *Ecosystem management in the United States: an assessment of current experience*. The University of Michigan and The Wilderness Society. Island Press, Washington, D.C. 352. pp. (Note: Includes examples from Wisconsin, e.g., Chequamegon National Forest Landscape Analysis and Design, Karner Blue Butterfly Habitat Conservation Plan, Marathon County Forest.)
- Ziebell, T. 2008. Nesting waterbirds of Rush Lake, is there a future? *The Passenger Pigeon* 70(1):19–23.



About the Authors

JERRY BARTELT (retired) was the Wildlife and Forestry Research section chief for the Wisconsin DNR, Bureau of Science Services from 1991 to 2007. Prior to that, he was a research scientist for the Wisconsin DNR Bureau of Research, studying waterfowl and predator-prey relationships since 1978. Recent interests and activities have been ecosystem and landscape-scale management, adaptive resource management, and ecologically sustainable management practices that are economically profitable and socially acceptable. He has been involved with many multi-scale planning efforts at both the state and multi-state level. He has a B.S. in Zoology from University of Wisconsin-Oshkosh and a M.S. in Wildlife Ecology from University of Wisconsin-Madison. His primary role in the “Ecological Landscapes of Wisconsin” project has been preparing sections on the fauna, climate, disturbance, and integrated opportunities, reviewing and editing the document, and coordinating the peer review and overall project.

OWEN BOYLE has been Species Management section chief for the Wisconsin DNR Bureau of Natural Heritage Conservation since 2014. His previous roles with the agency were Southeast Region Ecologist (2004–2012) and statewide Citizen-based Monitoring coordinator (2012–2014). He has worked on a variety of projects focusing on the conservation of biodiversity in Wisconsin from landscape-scale planning to population-level monitoring of declining animal and plant species. Owen received a B.S. in Natural Resource Management from Rutgers University and a Ph.D. in Botany from UW-Madison and is certified as a Senior Ecologist by the Ecological Society of America. His primary role in the “Ecological Landscapes of Wisconsin” project has been assisting with the preparation of the ecological landscape chapters, reviewing and editing, and providing administrative support.

ERIC EPSTEIN (retired) served as staff ecologist for the Natural Heritage Inventory program, housed within Wisconsin DNR’s Bureau of Endangered Resources from 1985 until 2008. His primary work areas during that time included designing, coordinating, and conducting field inventories for natural communities and rare species across the state. The information gathered during these efforts was interpreted and incorporated into various planning efforts by the DNR and many others, including numerous private entities. Prior to 1985, he worked as an inventory specialist for the State Scientific Areas program, which was then in Wisconsin DNR’s Bureau of Research, and for the Ecological Services Division of the U.S. Fish and Wildlife Service in Green Bay, Wisconsin. Professional areas of special interest include large-scale conservation design, landscape pattern and process, the Great Lakes, and big muddy rivers. His primary role in the “Ecological Landscapes of Wisconsin”

project has been preparing sections on flora, natural communities, and management opportunities, preparing Chapter 7, “Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin,” reviewing and editing the document, locating and placing photos in the book, and preparing photo captions.

VERN EVERSON (retired) worked as a Forest Resource Analyst in Wisconsin DNR’s Division of Forestry since 1997. Primary work has included: (1) analyzing Wisconsin forest trends and conditions and the Wisconsin forest products industry based on USDA Forest Service, Forest Inventory and Analysis (FIA) data and other inventory and economic data; (2) providing forest inventory and economic data and analysis to customers and partners in the private and public sectors; and (3) administering the state-funded intensification of the USDA Forest Service, Forest Inventory and Analysis on Wisconsin forestlands. Vern received a bachelor’s degree in Business Administration from UW-Whitewater and an M.S. degree in Forestry from UW-Madison. His primary role in the “Ecological Landscapes of Wisconsin” project has been preparing the socioeconomic sections of the publication.

DREW FELDKIRCHNER has been the Director of the Bureau of Natural Heritage Conservation since 2016. Prior to that, he was the Division of Forestry Liaison with the DNR’s Bureau of Natural Heritage Conservation since 2007. Before that, he coordinated biotic inventory projects for the Natural Heritage Inventory Program for six years. Drew received B.S. and M.S. degrees in Forest Science from the University of Wisconsin-Madison, primarily studying carbon and nutrient cycling in forest ecosystems. His position responsibilities and professional interests are focused on ways to maintain biodiversity in Wisconsin forests. His primary role in the “Ecological Landscapes of Wisconsin” project has been preparing sections on conservation design and assessment of northern forest communities, reviewing and editing text, providing graphics, and finding and providing photos to illustrate the publication.

COLLEEN MATULA is the Wisconsin DNR Forest Ecologist/Silviculturist for the Forestry Division since 2001. Prior to that, she was with the U.S. Forest Service in the Botany and Forestry programs on the Ottawa National Forest for ten years. Colleen’s work related interests include forest ecosystem monitoring, using silvicultural adaptive management, and terrestrial invasive species. She coordinates a variety of silvicultural training programs for the region and the state. She has participated in many multi-scale planning efforts, especially several state forest master plans. Her primary role in the “Ecological Landscapes of Wisconsin” project has been preparing sections on invasive species and disturbance sections.

EUNICE PADLEY worked at Wisconsin DNR beginning in 2001 as a Forest Ecology/Silviculture staff specialist in Division of Forestry and then as a Forest Research Ecologist with the Bureau of Science Services. Before that, she was with the U.S. Forest Service at the Regional Office in Milwaukee and worked on two National Forests in Michigan. Currently she is the National Forester with the U.S. Natural Resource Conservation Service in Washington D.C. She has worked on a variety of forest ecology topics, including forest soils, landscape ecology, ecological land classification systems, and National Forest management plans. She has a B.S. in Botany and a M.S. in Soil and Crop Science, both from the University of Wisconsin-Platteville, and a Ph.D. in Forestry from Michigan State University. Her primary role in the “Ecological Landscapes of Wisconsin” project has been preparing sections on the physical environment and disturbance, and preparing the “Changes during the Holocene” section in Chapter 4, as well as reviewing and editing.

JEFF SCHIMPF was an Environmental Analysis and Review Specialist with Wisconsin DNR. He received a B.S. in Biology in 1972 and an M.S. in Land Resources in 1989, both from the University of Wisconsin-Madison. He has worked with

the Wisconsin DNR in sewage treatment projects oversight and funding, state floodplain management planning, urban stream restoration, mining impact evaluation, and energy project impact review. His role with the “Ecological Landscapes of Wisconsin” project has been to prepare the sections on hydrology and aquatic fauna as well as to research aquatic resources topics and solicit input from the various Wisconsin DNR water-related programs.

ANDY STOLTMAN has been with the Wisconsin DNR since 2004 and worked as a Research Scientist in the Bureau of Science Services and as a GIS Specialist for the Division of Forestry. He has worked on numerous master planning projects for state properties as well as many other GIS consulting, mapping, and analysis projects. Currently Andy works with the Forest Products Services Team in the Division of Forestry. He earned his B.S. in Zoology/Anthropology and an M.S. in Forest Ecology and Management, both from the University of Wisconsin-Madison. His primary responsibilities with the *Ecological Landscapes of Wisconsin* project have been preparing the sections on vegetation and land cover and Native American Indians, cartography of the maps, and data analysis.



Funding

Funding for this project and publication of this report was provided by the Wisconsin Department of Natural Resources Divisions of Forestry, Lands, and Enforcement and Science; by grants from the Wisconsin Wildlife Action Plan Fund; and in part by funds from the Federal Aid to Wildlife Restoration Act under Pittman-Robertson Project W-160-P.



Contributors

Important technical reviews and editing were done by Wisconsin Department of Natural Resources Ecosystem Management Planning Team members Cathy Bleser and Lisa Helmuth on various topics covered by this book.

Detailed discussions on various topics covered by this publication were held with Andy Paulios, Mike Mossman, Bill (William A.) Smith, Sumner Matteson, Tom Bernthal, Pat Trochlell, Matt Dallman, and Randy Hoffman.

John Lyons provided much needed expertise and advice on fish and aquatic ecology and provided technical review of the aquatic sections.

Julie Bleser interpreted Natural Heritage Inventory data, provided tables of endangered, threatened, and special concern species, and made distribution maps of rare species and natural community occurrences.

Dawn Hinebaugh provided maps and other information on the Wisconsin DNR's State Natural Areas program.

Peter David (Great Lakes Indian Fish and Wildlife Commission) provided data on wild rice lakes in the Ceded Territories as well as many useful comments.

David Hvizdak, Massachusetts state soil scientist, formerly Natural Resources Conservation Service Major Land Resource Areas project coordinator in northwest Wisconsin, provided information on soils and glacial geology.

Dr. James B. Stoltman (UW-Madison Emeritus Professor of Archeology) provided invaluable information, advice, and consultation on the text on American Indian history.

Yoyi Steele provided the shapefiles for Important Bird Areas.

Mitch Moline, Kate Barrett, Bill Shockley, Nina Janicki, Sally Dahir, Kathy Hanson, Elizabeth Spencer, and Jennifer Skoloda performed GIS analyses, prepared maps, and provided other background materials.

Sarah Herrick and Jescie Kitchell provided editorial assistance and compiled data and other needed materials for this document.

Sarah Shapiro Hurley, Signe Holtz, Darrell Zastrow, Paul DeLong, Laurie Osterndorf, Mark Aquino, Jack Sullivan, Karl Martin, and Steve Miller provided important administrative support for the project.



Credits

Publication assistance was provided by Dreux Watermolen.

Patricia Duyfhuizen provided the edit, organizational advice, graphic design, and technical layout as well as many other helpful editing suggestions.

Michelle Voss prepared graphs and provided assistance with other figures.

Andy Stoltman, Wisconsin DNR-Forestry, produced the maps and prepared other cartographic presentations found in this publication.

The Wisconsin Department of Natural Resources provides equal opportunity in its employment, programs, services, and functions under an Affirmative Action Plan. If you have any questions, please write to the Equal Opportunity Office, Department of Interior, Washington, D.C. 20240.

This publication is available in alternative format (large print, Braille, audio tape, etc.) upon request. Please call the Wisconsin Department of Natural Resources, Bureau of Science Services, at 608-266-0531 for more information.



Printed on recycled paper

Wisconsin Department of Natural Resources

P.O. Box 7921, Madison, WI 53707

PUB-SS-1131Z 2015